Lightning

lightning - a luminous, electrical discharge in the atmosphere caused by the electric-charge separation of precipitation particles within a cumulonimbus, or thunderstorm, cloud.

thunder – is the resulting sound wave caused by the sudden expansion of air heated by a lightning discharge.

LIGHTNING FACTS

Lightning is a component of all thunderstorms.

There are more than 40,000,000 cloud to ground lightning flashes every year in the continental United States.

Worldwide, there are approximately 100 lightning flashes each second.

Lightning heats the surrounding air to greater than 50,000 degrees Fahrenheit. The quick heating and cooling of the air causes a shock wave which produces thunder.

A lightning flash contains enough energy to supply several homes with power for a month.

The speed of lightning traveling from cloud to ground approaches one-third the speed of light.

On average, 300 people are injured and 89 people are killed by lightning each year, making lightning nature's number 2 killer, second only to flash floods.

Your chances of being struck by lightning are estimated to be 1 in 600,000.

Secondary effects from lightning include fires, power disruption, and damage to objects struck by the flash. Effects from thunder include startling people, causing jerk reactions.

According to the National Lightning Safety Institute (NLSI), lightning causes more than 26,000 fires annually in the United States. In 1997, in Denver, a warehouse fire caused by lightning resulted in a $70 million loss.

The NLSI estimates property damage, increased operating costs, production delays and lost revenue from lightning and secondary effects to be in excess of $6 billion per year.

(Sources: National Weather Service 2004, National Lightning Safety Institute, 2000; Severe Weather…Stats & Facts; FEMA, 1997; U.S. Dept. of Commerce, 1994)

Fort Collins, Colorado. Taken from atop CSU Atmospheric Science building. Photo by Stephen Hodanish, reprinted with permission.

Pueblo Reservior. Photo by Stephen Hodanish, reprinted with permission.

The table below shows a summary of deaths, injuries, and damage costs in the continental United States from 1996 through 2003 due to lightning.

Summary of Deaths, Injuries, and Damage Costs Due to Lightning: 1996-2003

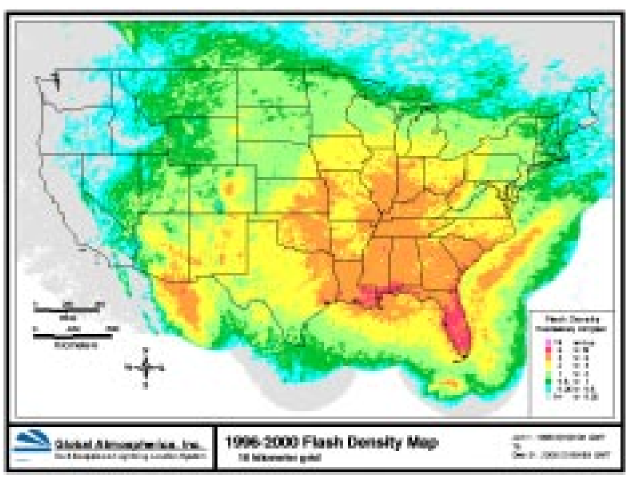
Year	Deaths	Injuries	Property Damage ($Millions)	Crop Damage ($Millions)
1996	52	309	34.4	0.1
1997	42	306	40.3	0.3
1998	44	283	38.0	3.1
1999	46	243	32.5	0.0
2000	51	364	39.8	0.1
2001	44	371	43.6	2.0
2002	51	256	43.5	0.0
2003	44	237	25.6	0.0
TOTAL	374	2,369	297.7	5.6

Source: www.nws.noaa.gov/om/hazstats.shtml

The table to the right demonstrates the number of deaths in nine states attributed to lightning from 1995 to 2003 according to the National Weather Service's hazardous statistics database. Florida had the most with 80, Iowa had 55, Texas had 31, and Colorado had the fourth highest with 28.

NINE STATES WITH THE MOST DEATHS ATTRIBUTED TO LIGHTNING: 1995-2003	
STATE	TOTAL
Alabama	17
Colorado	28
Florida	80
Georgia	14
Iowa	55
Louisiana	16
North Carolina	16
Ohio	21
Texas	31
Source: www.nws.noaa.gov/om/hazstats.shtml	

The following map of the United States is a flash density map for the period 1996-2000. Note that most of the cloud to ground lightning occurring over the United States occurs over the southeastern part of the country. Florida leads the nation for lightning. Approximately 22 million lightning flashes occur over the United States per year. As can be seen, many other states have more lightning than Colorado. There is a misconception that Colorado is 2nd in the nation with respect to the amount of cloud to ground lightning. This is not true. The Centennial State ranks 26th in the nation with respect to the amount of cloud to ground lightning. This map is courtesy of Global Atmospherics." (http://www.glatmos.com).

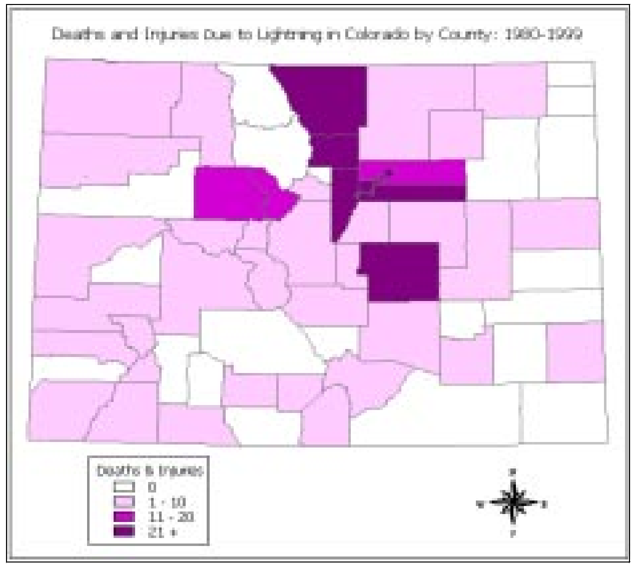


Reprinted from http://www.crh.noaa.gov/pub/ltg/crh_flash_map.html

LIGHTNING HAZARD IN COLORADO

In a study in the Colorado area, it was found 1 out of 52 lightning flashes results in an insurance claim- www.crh.noaa.gov/pub/ltg/crh_ltg_facts. html.

The following map and table depict the number of deaths and injuries attributed to lightning from 1980 through 1999, as reported by the NOAA's Colorado Lightning Resource Center at www.crh.noaa.gov/pub. Over the 22-year period, 65 lightning-related deaths and 305 injuries were reported.



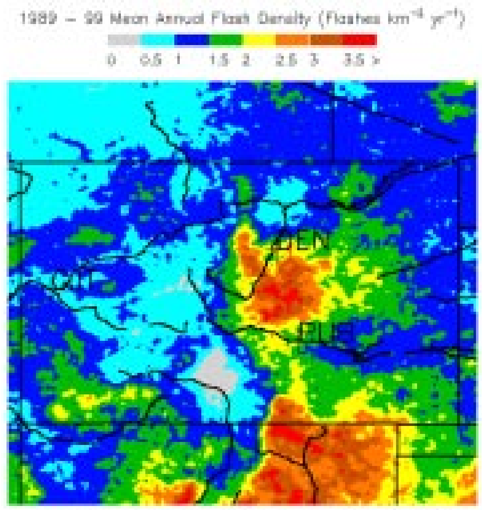
LIGHTNING DEATHS AND INJURIES IN COLORADO: 1980-2002		
COUNTY	DEATHS	INJURIES
Adams	2	12
Alamosa	0	1
Arapahoe	3	23
Archuleta	0	3
Boulder	4	27
Chaffee	2	3
Clear Creek	0	5
Costilla	0	1
Denver	3	22
Douglas	1	8
Eagle	2	9
El Paso	8	45
Elbert	1	0
Fremont	1	0
Gunnison	0	2
Huerfano	0	9
Jefferson	6	31
Kit Carson	0	2
La Plata	1	4
Lake	0	2
Larimer	4	38
Lincoln	0	1
Logan	0	1
Mesa	1	3
Moffat	1	0
Montezuma	1	3
Montrose	1	1
Morgan	1	4
Otero	1	0
Ouray	1	0
Park	3	1
Pitkin	3	2
Prowers	1	3
Pueblo	1	5
Rio Blanco	1	1
Rio Grande	3	1
Routt	3	4
San Juan	1	5
San Miguel	0	3
Summit	1	11
Teller	3	1
Weld	0	7
Unknown	0	1
Total	65	305
Source: www.crh.noaa.gov/pub/ltg/crh_LTG_county_stats.html		

The following section is reprinted from the Colorado Lightning Resource Center website at http://www.crh.noaa.gov/pub, then click "lightning".

Lightning Flash Density Map For Colorado

"Below are lightning flash density maps for Colorado ... This map shows the number of cloud to ground lightning flashes per square kilometer per year. To convert to cloud to ground flashes per square mile per year, multiply the value on the map by 2.59.

COLORADO



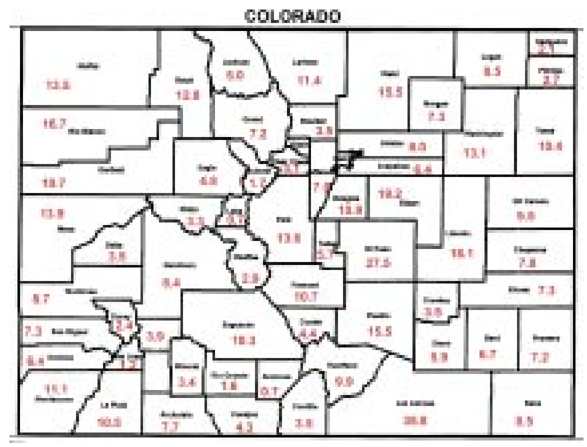
Courtesy of the Lightning Project at Texas A&M University

The data above shows the average number of cloud to ground lightning flashes per year for the state of Colorado and surrounding areas. Eleven years of lightning data (1989 to 1999) were collected to make this plot. The black lines in the plot represent major rivers which run through the state. Denver (DEN), Grand Junction (GJT) and Pueblo (PUB) are shown. The brightest red regions indicate the most lightning activity. You can expect more than 3.5 cloud to ground (CG) lightning flashes to hit the ground in a 1 square kilometer area. Converting this to square miles, you can expect about 9 CG flashes to hit the ground per square mile. The least amount of activity occur in the San Luis Valley, the central mountain regions, and the Upper Arkansas river valley. The primary "hot spot" for lightning in Colorado is the greater Pikes Peak region, including Colorado Springs. Another hot spot is in the Trinidad area (Raton Mesa). The reason why so much lightning occurs in these regions is due to a combination of topography, low level wind flow regime, and low level atmospheric moisture.

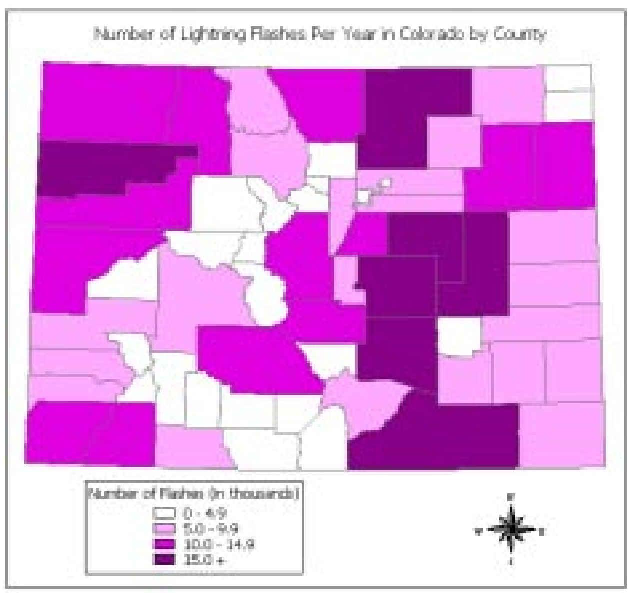
Approximately 494,000 cloud to ground lightning flashes occur in Colorado every year. The map above is courtesy of the Lightning program at Texas A&M."

The following section is reprinted from the Colorado Lightning Resource Center, National Weather Service, Pueblo (http://www. crh.noaa.gov/pub/ltg/crh_ltg_per_county.html).

"Estimated number of Cloud to Ground (CG) lightning flashes which occur in each county in Colorado per year. These values were gathered by estimating the average flash density for each county, and then multiplying this value by the size of the county. Gilpin and Denver counties had values of 1.6 and 1.2 respectively (Numbers are in thousands). The actual average amount of cloud to ground lightning for the entire state of Colorado is 494,000 flashes per year."



Reprinted from http://www.crh.noaa.gov/pub/ltg/crh_ltg_per_county.html



The map following this section depicts the counties in which humans are most at risk from personal injury from lightning, excluding fire risks. Calculations were based on the following:

The numbers of deaths and injuries for each county were assigned a value as follows:

Number of Deaths and Injuries	Value
21+	3
11-20	2
1-10	1
0	0

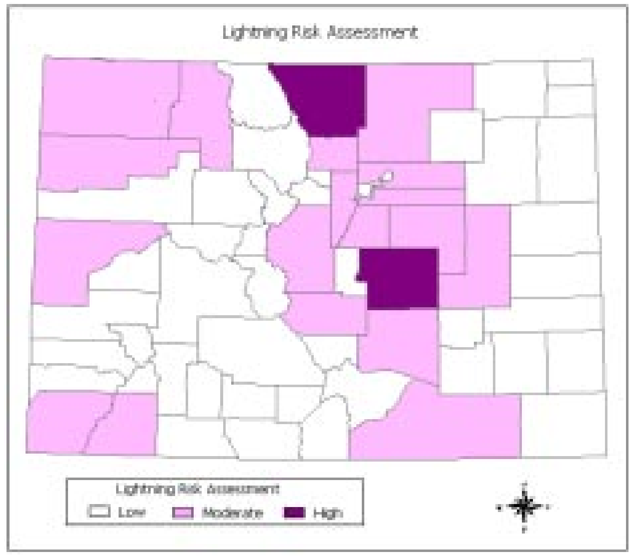
The number of lightning flashes in each county per year were assigned values:

Lightning Flashes	Value
15.0 +	3
10.0-14.9	2
5.0-9.9	1
0-4.9	0

The value of deaths/injuries was added to the value assigned to the lightning flashes. The resulting values range from 0 to 6. Values from 5 to 6 represent areas determined to be at high risk. Values from 3-4 represent areas with moderate risk and values less than 3 represent areas with low risk.

Lightning Risk in Colorado by County					
County	Deaths & Injuries	Rank	Lightning Flashes	Rank	Combined Rank
El Paso	46	3	27.5	3	6
Larimer	39	3	11.4	2	5
Pueblo	6	1	15.5	3	4
Jefferson	32	3	7.0	1	4
Arapahoe	25	3	6.4	1	4
Elbert	1	1	19.2	3	4
Weld	7	1	15.5	3	4
Rio Blanco	2	1	16.7	3	4
Boulder	25	3	3.5	0	3
Adams	13	2	8.0	1	3
Las Animas	0	0	35.8	3	3
Lincoln	0	0	18.1	3	3
Moffat	1	1	13.5	2	3
Routt	7	1	12.8	2	3
Montezuma	1	1	11.1	2	3
La Plata	5	1	10.5	2	3
Mesa	4	1	13.9	2	3
Douglas	8	1	10.9	2	3
Park	4	1	13.6	2	3
Fremont	1	1	10.7	2	3

For more information on lightning and safety in Colorado, visit the Colorado Lightning Resource Center, National Weather Service website at http://www.crh.noaa.gov/pub then "lightning".



Mitigation activities in high-risk areas should have priority. High-risk areas include sections of El Paso and Larimer Counties. Moderate risk areas include sections of Adams, Arapahoe, Boulder, Douglas, Elbert, Fremont, Jefferson, La Plata, Las Animas, Lincoln, Mesa, Moffat, Montezuma, Park, Pueblo, Rio Blanco, Routt, and Weld Counties.

Mitigation activities should focus on increasing education, and improving communication and life safety activities. Public education and information should be developed, improved, and disseminated on a continual basis. Public information should lead property owners and renters to property improvements designed to prevent physical damage. Improving communications involves getting, replacing, and testing warning systems such as sirens and weather radio to alert persons to severe storm activity in the vicinity. Many areas of the state do not have severe weather alert capabilities; transmission stations should be encouraged. Lightning safety skills should be exercised in regular trainings.

Pueblo West
Photo by Stephen Hodanish, reprinted with permission.

Precipitation

precipitation - rainfall

RAIN FACTS

In 1939, the record minimum annual precipitation (through 1998) in Colorado was set at the Buena Vista station (elevation 7,980 feet) with 1.69 inches.

The record maximum annual precipitation (through 1998) in Colorado was 92.84 inches, at the Ruby station in 1897, estimated elevation of 10,000 feet.

The record maximum 24-hour precipitation in Colorado (through 1998) was 11.08 inches, set at the Holly station in 1965, estimated elevation of 3,390 feet.

The record maximum 24-hour precipitation in the United States (through 1998) was estimated at 43 inches, set in Texas at the Alvin station in 1979.

The record maximum annual precipitation (through 1998) in the United States was 704.83 inches, at the Kukui station in Hawaii in 1982.

In 1929, the record minimum annual precipitation (through 1998) in the United States was set at the California Death Valley station with 0.00 inches.

Too little or too much precipitation can greatly influence other natural hazards such as drought, wildfire, and floods.

(Source: http://lwf.ncdc.noaa.gov/oa/climate/severeweather/rainfall.html)

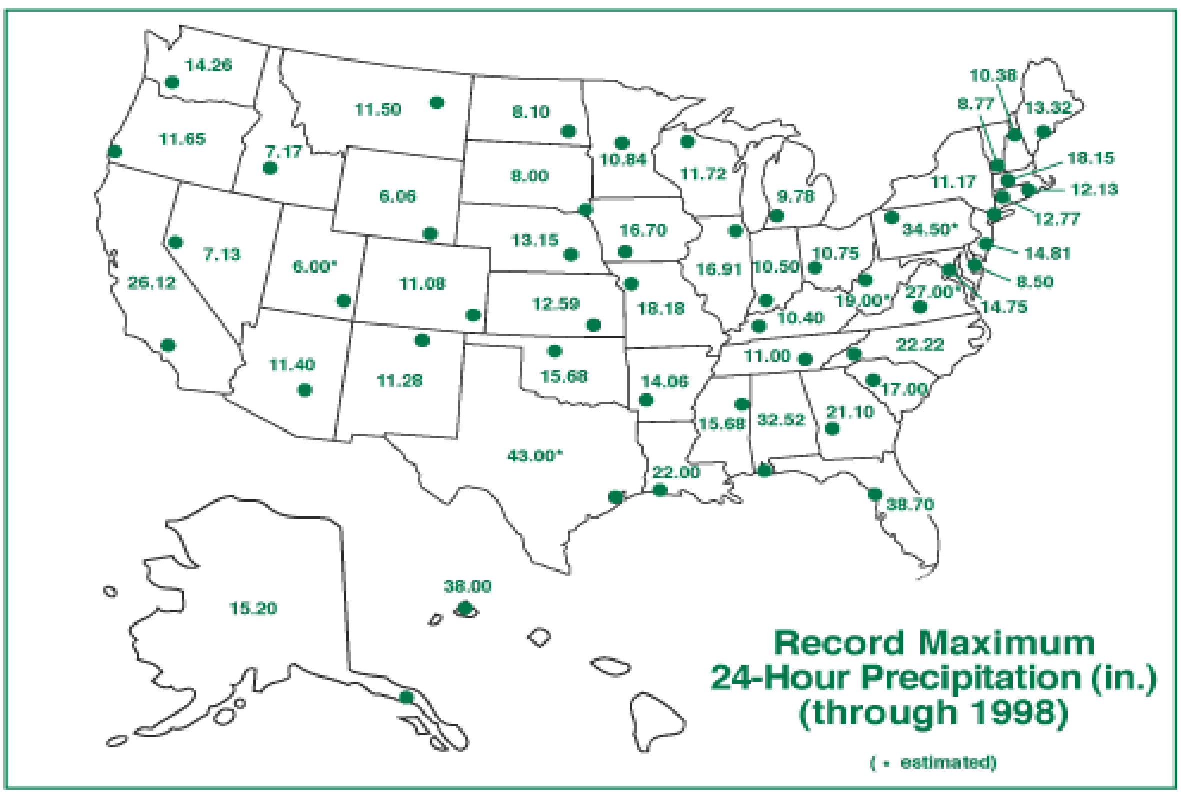
The following information, compiled from National Weather Service statistics, is a summary of reported deaths, injuries, and damage costs attributed to precipitation in the United States from 1996 to 1998.

Summary of Reported Deaths, Injuries, and Damage Costs Due to Precipitation in the United States: 1996-2003

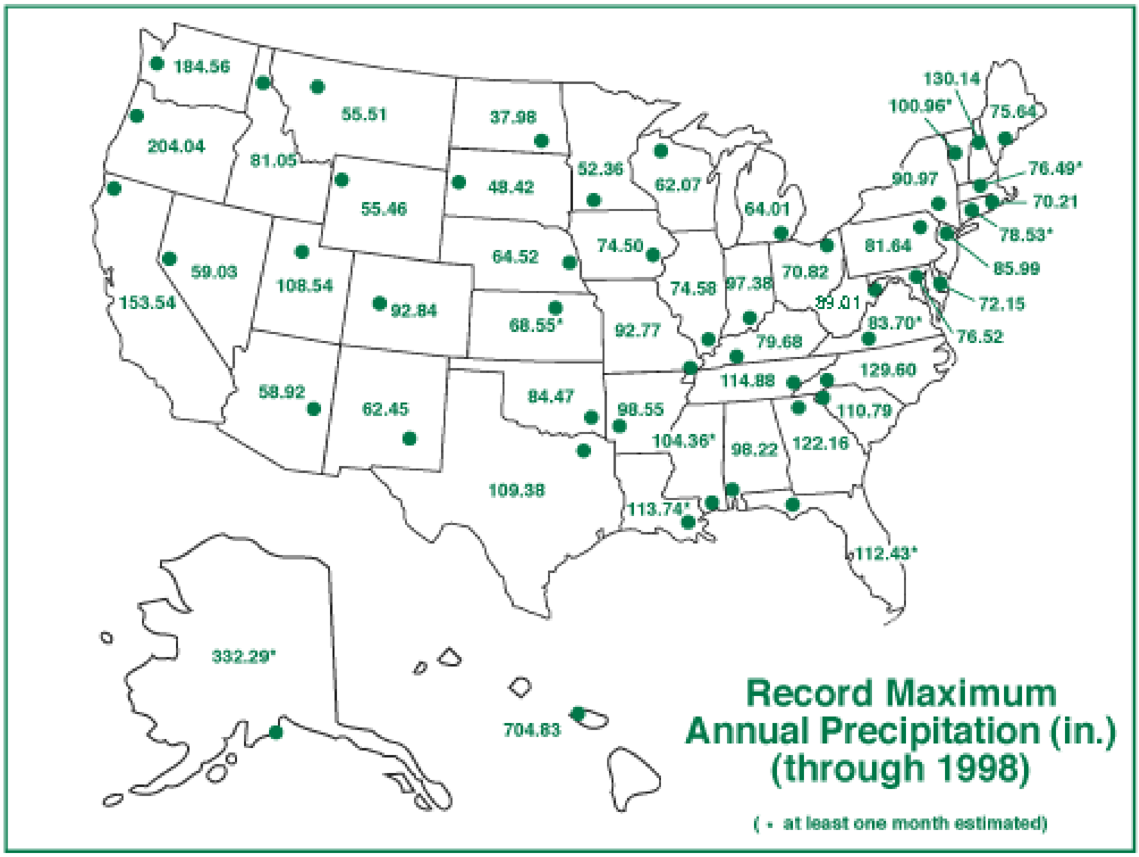
Year	Deaths	Injuries	Property Damage ($Millions)	Crop Damage ($Millions)
1996	9	5	48.1	1.5
1997	33	29	11.4	0.7
1998	11	24	45.3	321.1
1999	8	7	30.3	0.0
2000	4	38	4.4	4.1
2001	3	1	20.7	21.5
2002	1	1	0.8	1.1
2003	5	34	8.4	69.8

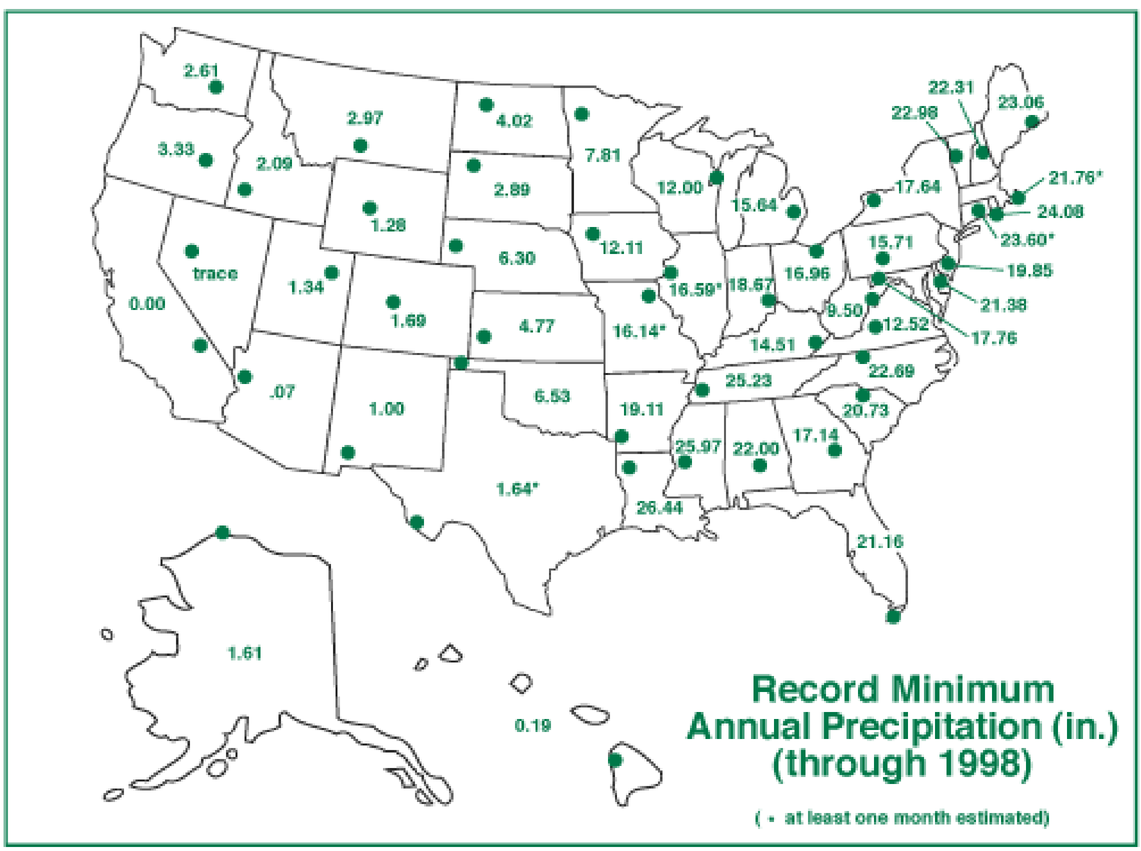
Sources: www.nws.noaa.gov/om/severe_weather/

The map below shows the record maximum 24-hour precipitation in inches for each state through 1998. This map was reprinted from http://lwf.ncdc.noaa.gov/oa/climate/severeweather/rainfall.html.



The maps and table show the recorded minimum and maximum annual precipitation by state through 1998.
Maps reprinted from http://lwf.ncdc.noaa.gov/oa/climate/ severeweather/rainfall.html.



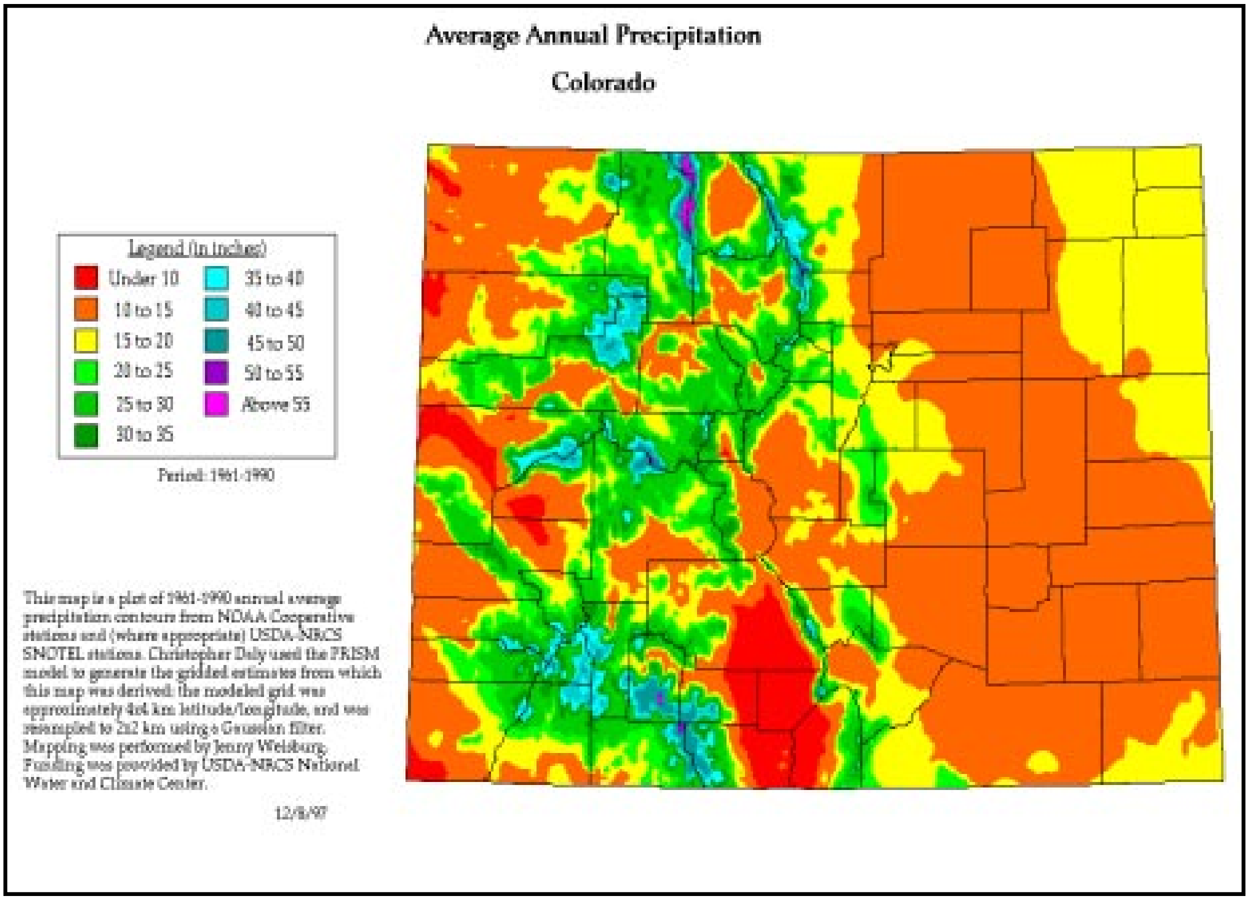


Record Minimum and Maximum Annual Precipitation in the United States by State: through 1998		
State	Minimum Precipitation (Inches)	Maximum Precipitation (Inches)
Alabama	22.00	98.22
Alaska	1.61	332.29
Arizona	0.07	58.92
Arkansas	19.11	98.55
California	0.00	153.54
Colorado	1.69	92.84
Connecticut	*23.60	*78.53
Delaware	21.38	72.75
Florida	21.16	*112.43
Georgia	17.14	122.16
Hawaii	0.19	704.83
Idaho	2.09	81.05
Illinois	*16.59	74.58
Indiana	18.67	97.38
Iowa	12.11	74.50
Kansas	4.77	68.55
Kentucky	14.51	79.68
Louisiana	26.44	*113.74
Maine	23.06	75.64
Maryland	17.76	76.52
Massachusetts	21.76	*76.49
Michigan	15.64	64.01
Minnesota	7.81	52.36
Mississippi	25.97	*104.36
Missouri	*16.14	92.77
Montana	2.97	55.51
Nebraska	6.30	64.52
Nevada	Trace	59.03
New Hampshire	22.31	130.14
New Jersey	19.85	85.99
New Mexico	1.00	62.45
New York	17.64	90.97
North Carolina	22.69	129.60
North Dakota	4.02	37.98
Ohio	16.96	70.82
Oklahoma	6.53	84.47
Oregon	3.33	204.04
Pennsylvania	15.71	81.64
Rhode Island	24.08	70.21
South Carolina	20.73	*110.79
South Dakota	2.89	48.42
Tennessee	25.23	114.88
Texas	*1.64	109.38
Utah	1.34	108.54
Vermont	22.98	*100.96
Virginia	12.52	*83.70
Washington	2.61	184.56
West Virginia	9.50	89.01
Wisconsin	12.00	62.07
Wyoming	1.28	55.46
* - At least one month estimated. Source: www.ncdc.noaa.gov/ol/climate/severeweather/a-thigh.gif		

Heavy precipitation can cause many problems. Pictures below show that during a brief but heavy period of rainfall, a storm water drain quickly became inundated with moving water. Water flew down the street and sidewalks, sweeping loose items along.

Photos provided by COEM

The map below depicts the average annual precipitation in Colorado. A detailed description is on the map. Note that there are areas in the San Luis Valley and in the western counties that, on average, receive less than ten inches of precipitation annually. Areas along Routt and Jackson Counties receive the highest average amounts of precipitation.



Precipitation Extremes

The Big Thompson Canyon flood on July 31, 1976 yielded up to ten inches of rain in a few hours over the basin.

As a result of storms from July 28-August 12, 1997, 13 counties received a presidential disaster declaration. These counties are Larimer, Weld, Morgan, Logan, Phillips, Clear Creek, Elbert, Kiowa, Baca, Otero, Lincoln, Crowley, and Prowers.

Heavy storms from April 29-May 1, 1999 caused flooding, mudslides, and landslides resulting in a presidential disaster declaration. Rainfall totals of up to 13 inches were recorded in the Cheyenne Mountain region of Colorado Springs. Counties declared were Bent, Crowley, Custer, El Paso, Elbert, Fremont, Kiowa, Larimer, Otero, Las Animas, Pueblo, and Weld.

-From the Colorado Flood Hazard Mitigation Plan 1999

Subsidence

subsidence - "… the sinking of the land over man-made or natural underground voids. In Colorado, the type of subsidence of greatest concern is the settling of the ground over abandoned mine workings." (From CGS Special Publication 12, http://geosurvey.state. co.us/pubs/geohazards/docs/sp12.htm).

SINK HOLES
Natural and human activities cause subsidence.

Human activities cause subsidence. Activities that lead to subsidence include underground mining, pumping groundwater or petroleum out of the ground, hydrocompaction, and draining organic soils.

Natural causes of subsidence include the development of sinkholes, rock sliding downward along faults, natural sediment compaction, and melting of permafrost.

Subsidence affects at least forty-five states.

FEMA estimates that average losses in the United States from subsidence are over $125 million a year.

Building, utility, and road damage and decreased property values may result from subsidence.

Subsidence may occur quickly or slowly. An example of a quick event is the collapse of the roof of an underground coal mine. An example of a slow event is the compaction of sediment from removal of underground water.

Flooding may increase as a result of subsidence.

Most homeowners' insurance policies specifically exclude subsidence events.

Over 1,000 participants are currently enrolled in the Mine Subsidence Protection Program in Colorado. This program was set up to pay for damage to homes resulting from subsidence due to coal mining.

Sources: http://www.dnr.state.co.us/geology/subsidence.html; FEMA 1997

SUBSIDENCE HAZARD IN COLORADO
The following section is reprinted from the Colorado Geological Survey. For complete information on subsidence, refer to http://geosurvey.state.co.us.

The following is reprinted from Colorado Geological Survey Special Publication 12 at http://geosurvey.state.co.us/ pubs/geohazards/docs/sp12.htm.

Characteristics
Subsidence may occur abruptly-virtually instantly-or gradually over many years. It may occur uniformly over a wide area as local depressions or pits separated by areas which have not visibly subsided. In Colorado, it is most common in the sedimentary rocks over abandoned coal and clay mines. The crystalline rocks in which most metals are mined have greater strength and are less likely to settle or collapse. Subsidence can also occur where underground water has dissolved subsurface materials or has been withdrawn by wells. Although serious in other western states, these latter types of subsidence are less common in Colorado than sinking caused by the caving in of underground mine workings. Subsidence caused by collapsing soils is discussed under the heading Collapsing Soils.

Consequences
Subsidence can result in serious structural damage to buildings, roads, irrigation ditches, underground utilities and pipelines. It can disrupt and alter the flow of surface or underground water. Surface depressions created by subsidence may be filled in, only to sink further because the underground void has not been completely closed. Areas may appear to be free of subsidence for many years and then undergo renewed gradual or even drastic subsidence.

Aggravating Circumstances
Weight, including surface developments such as roads, reservoirs, and buildings, and man-made vibrations from such activities as blasting, heavy truck or train traffic can accelerate the natural processes of subsidence. Fluctuations in the level of underground waters caused by pumping or by injecting fluids into the earth can initiate sinking to fill the empty space previously occupied by water or soluble minerals.

Mitigation
Recognition of past subsurface mining activity, including the study of mine maps, can help identify potential problem areas so precautions can be taken to prevent or minimize property damage on the surface of the ground. The surest way to avoid structural damage is not to build above underground voids. Also, detailed engineer geologic analyses may show that some areas over an underground mine may be stable because of previous subsidence or because the specific site was not mined out. Some

times special structural designs can compensate for future ground movement. Backfilling of the voids before construction can stabilize the surface, but usually at prohibitive cost.

Subsidence is characteristic of some lands underlain by formations containing soluble rocks (for example, the Eagle Valley evaporite, which contains rock salt and gypsum). It is usually very difficult to accurately predict the exact location or time of any future subsidence from this cause because of the many variables.

Land Use

Unless property damage can be prevented or alleviated, subsidence-prone lands are best used for farming, open space, landfills, open storage areas or surface mineral extraction. Special construction methods can be used for roads and pipelines spanning subsidence-prone land. Corrective measures after subsidence has occurred are usually very expensive. Sometimes maps of underground mines help in relating subsidence-prone areas with proposed surface development. Most problems can be solved using a combination of geologic knowledge and special engineering design and construction methods. Investigations and special engineering designs are costly. In many cases avoidance or selective land use is the only economic and safe solution.

Case History

One evening in 1974 a Lafayette, Colorado, trailer park resident noticed a two-foot hole in his front yard. By morning the hole was 10 feet deep and 10 feet across. The trailer was moved as the hole continued to grow until it was about 25 feet deep and 25 feet in diameter. The sidewalk, a telephone pole, a concrete pad and a fence had to be replaced after the hole was filled. Fortunately a gas line exposed by subsidence did not rupture. The property owner backfilled the hole, acknowledging the site had previously subsided and had been filled. An inclined shaft to an old coal mine underlies the site. The workings were abandoned more than 50 years ago.

Case History

Interstate Highway 25 crosses several abandoned coal mines in Weld County. Roadway settlement of more than two feet near Erie has taken place in patterns that can be closely correlated to subsidence over coal mine workings 350 to 400 feet below the surface. Much of the severely damaged road is now below original grade, resulting in a mild roller coaster like ride. Estimates for repair of the ¾ mile section damaged by subsidence are about $1 million.

Case History

Friday, April 13, 1979, was a lucky day for a group of Colorado Highway Department workers and passersby. Maintenance crews found a 500 foot deep airshaft to the abandoned Klondike coal mine had been reopened by surface subsidence into the mine. A crater about 20 to 25 feet across opened like a funnel into the shaft just off the pavement on the northeast corner of the Interstate-25 Woodmen Park Road interchange near Colorado Springs. The shaft had previously been capped, but the slow deterioration of the surface plug finally caused this reopening. Proper filling and capping of this shaft can prevent future incidents.

Legal Definition

From CGS Special Publication 6 :H.B. 1041, 106-7-103(10): "Ground subsidence" means a process characterized by downward displacement of surface material caused by natural phenomena such as removal of underground fluids, natural consolidation, or dissolution of underground minerals, or by man-made phenomena such as underground mining.

Descriptive Definition

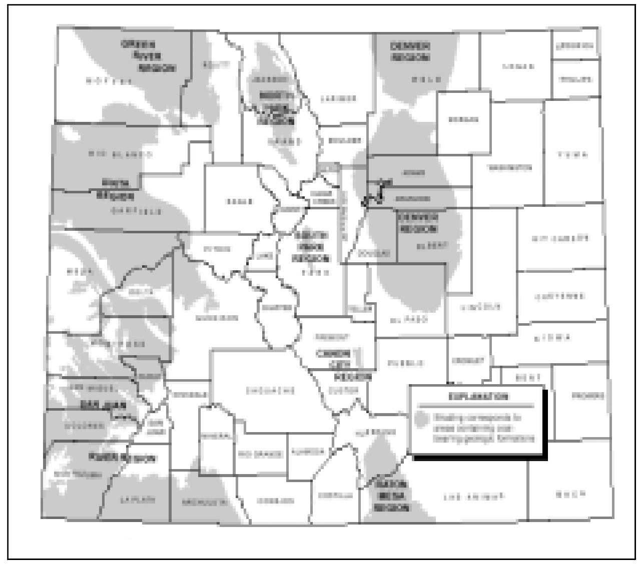
There are several distinct types of natural processes and man's activities that may produce ground subsidence. These are discussed and explained below under separate headings. In general, the type and severity of surface subsidence is governed by the amount of ground surface and the location of removal or compression, and the geologic conditions of a particular site. Some examples of the types of ground subsidence, and how they are affected or produced by geologic conditions are explained below.

Withdrawal of pore fluids,_usually ground water, is a common cause of ground subsidence. Massive lowering of the groundwater table by "mining" of ground water* in a poorly consolidated aquifer results in subsidence of the ground surface. We know of no documented cases of serious subsidence from ground-water withdrawal in Colorado; however, several areas of extremely thick and extensive alluvial aquifers may have that potential if intensive future ground water development occurs. This is especially true of such large intermontane basins as the San Luis Valley, Wet Mountain Valley, North and Middle Park, and parts of the Upper Arkansas Valley. A second kind of ground subsidence results from desiccation (drying up) of very wet clay deposits following lowering of the water table.

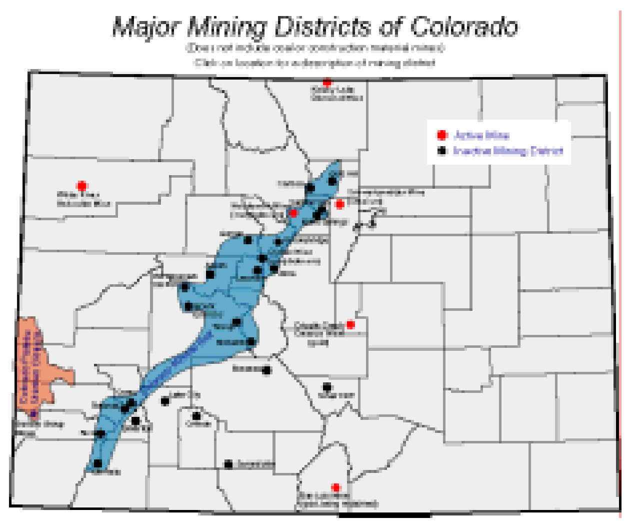
Hydrocompaction produces ground surface collapse from excessive wetting of certain low-density weak soils. This can occur in two general types of soil that are common in Colorado a) wind deposited silts (loess), and b) predominantly fine-grained colluvial soils. In either case, collapse occurs from excessive wetting of previously dry, collapsible soils. Wetting of these materials weakens the already weak or unstable soil structure, which undergoes internal collapse and densification (reduction of air voids). Densification of the weak soil column produces ground surface collapse and subsidence in the vicinity of excessive wetting. Removal of fine material by piping* is probably an additional factor in some cases of subsidence by wetting. Such excessive wetting can occur from irrigation, broken water lines, surface ponding, or drainage diversions. Dissolution of soluble rock or soil materials_also results in ground subsidence. This occurs in areas underlain by highly soluble rock formations-especially gypsum ($CaSo_4$. $2H_2O$), or halite (NaC1); and to lesser extent in limestone ($CaCO_3$) materials. Removal of earth materials by water solution leads to surface collapse. Hydrologic factors that may cause the solution and removal of material may be natural or man-induced. Natural solution is the result of the normal hydrologic processes of downward percolation of surface water and/or lateral movement of ground water within the water table (either the main ground water table or a perched water table). Man-induced hydrologic changes or activities can have much the same effect on soluble earth materials. Such activities include temporary or permanent stream channel changes, irrigation ditches, land irrigation leaking or broken pipes, temporary or permanent ponding of surface waters, the mining of soluble minerals by means of forced circulation of water within the earth. Soluble rock materials that are subject to possible ground subsidence underlie large areas of western Colorado.

Removal of support by underground mining is a common cause of ground subsidence in many areas of Colorado. Extensive removal of minerals, mineral fuels, rock aggregate, and other materials results in large underground void spaces. Subsequent natural processes including fracturing, chemical changes, caving, flowage, and other related adjustments often produce surface subsidence, fissures, and tilting of the land surface above and/or adjacent to the surface projection of underground workings. Man-induced changes in the hydrology of the underground workings and/or overlying rock and soil materials can affect subsidence. In addition to actual undermined areas, special hazards are posed by certain appurtenant structures such as air shafts and various other mine workings. Additional problems in identifying and delineating areas of potential subsidence include the presence of faults and other geologic complications, and the fact that "final mine maps" may not show the actual extent of mining. Also, discrepancies in survey ties between the mine maps and surface reference points may be sizeable.

Many undermined areas have incomplete or nonexistent records. Potential subsidence hazards from underground mine working and shafts exist in many parts of Colorado. These include areas of past and present coal mining, "hard rock" mining areas, and undoubtedly others.



Coal Regions in Colorado
Reprinted from http://geosurvey.state.co.us



Reprinted from http://geosurvey/pubs/geohazards/docs/mining.html

Severity of the Problem

Geologic conditions conducive to all of the basic types of subsidence described above exist in extensive areas of Colorado. Known serious problems of mining related subsidence, hydro-compaction, and dissolution subsidence are known to occur in the state. With increased demand for mineral fuels, other mining activities and pressures for intensive urban and recreational development throughout much of the state, these problems will intensify unless recognized and wisely dealt with. These guidelines are intended to help local governments to identify problem areas and prevent needless economic losses in the future development of the state.

Criteria for Recognition

The criteria for recognition of actual or potential ground subsidence conditions include a careful evaluation of all pertinent historic, geologic, and hydrologic factors or the area, and/or actual periodic measurements. Onset of actual or observed subsidence is in many cases related to changes in land use; accordingly land use changes in areas identified as having potential for subsidence should be carefully scrutinized.

Historic evidence includes common knowledge of long term area residents concerning characteristics of land under present and past usages. This kind of information is important but must be carefully evaluated for accuracy and objectivity. Additional sources of information include official records of state, local, and federal agencies (especially with respect to past mining activity). Unofficial sources of information include unofficial mine maps, newspaper accounts, and published books of a historical nature.

Engineering geologic factors should include a complete survey of existing geologic and engineering data that are available by way of a background study. These data will identify areas in a general way known to be underlain by geologic formations containing evaporite minerals, limestone, and potentially minable mineral deposits. More detailed information such as local geologic and engineering studies for highways or dam sites may reveal specific pertinent data and how similar geologic problems were (or were not) solved in areas of actual construction.

Knowledge of hydrologic factors is critical for evaluating most types of ground subsidence. Because of this, it is necessary to define hydrologic conditions to identify potential subsidence areas. The hydrologic analysis should include evaluation of all available geologic data as described above, but in a hydrologic context. Additional hydro-geologic data including published information, well logs, and field information from the site of the investigation should be compiled and evaluated. Finally the impacts of possible land uses should be evaluated as they apply to lands susceptible to ground subsidence.

The table to the right reflects the number of abandoned mines in Colorado by county as reported by the Colorado Geological Survey Division of Minerals and Geology. The Division reports the total number of abandoned mines to be over 23,000. A few injuries throughout the years have been attributed to mine subsidence. In 1975 a BLM employee was injured in a room collapse (subsidence) in a uranium mine. In May 1994 a woman was injured while hiking in the Mt Garfield area in Garfield County. She was injured when she fell into some subsidence cracks related to an abandoned coal mine fire.

Inactive Mine Reclamation Program

Since 1980, the program has safeguarded 4870 hazardous openings and reclaimed 1539 acres of abandoned mined land statewide. Project activities include: field investigations, project development, project design, realty work, construction contract bidding and management, site construction and reclamation, construction inspection, site monitoring and maintenance of prior project work.

-From http://mining.state.co.us/abandonedmines/inactivemine.html.

Abandoned Mines in Colorado by County

County	Inactive Mines	
	Coal	Other
Archuleta	14	5
Boulder	183	3,600
Chaffee	0	150
Clear Creek	0	3,000
Conejos	0	35
Custer	0	1,800
Delta	36	3
Dolores	0	210
Douglas	5	40
Eagle	0	100
El Paso	153	15
Fremont	279	50
Garfield	13	15
Gilpin	0	5,000
Grand	0	10
Gunnison	15	200
Hinsdale	0	50
Huerfano	178	0
Jackson	8	35
Jefferson	48	100
Lake	0	550
La Plata	60	50
Larimer	15	250
Las Animas	202	2
Mesa	33	150
Mineral	0	200
Moffat	31	15
Montezuma	26	10
Montrose	2	1,280
Ouray	0	350
Park	49	250
Pitkin	3	750
Rio Blanco	22	10
Rio Grande	0	30
Routt	77	44
Saguache	0	800
San Juan	0	500
San Miguel	7	700
Summit	0	600
Teller	0	1,100
Weld	36	0
Total	1,495	21,899

Source: http://mining.state.co.us/abandonedmines/inactivemine.html

Consequences of Improper Utilization

The consequences of improper utilization of land subject to ground subsidence will generally consist of excessive economic losses. This includes high repair and maintenance costs for buildings, irrigation works, highways, utilities and other structures. This results in direct economic losses to citizens, and indirect losses through increased taxes and decreased property values.

Mitigation Procedures

In certain extremely hazardous, localized areas of ground subsidence, complete avoidance is probably the most advisable course of action. Even these lands are usually amenable to reclamation and limited types of sequential uses.

Non-conflicting uses are the safest, surest, and most economically acceptable utilization of many lands subject to ground subsidence. In general, agriculture, parkland or other open space, and highly selective industrial uses are the most feasible.

Engineered design and construction is a third alternative. This should be reserved for areas of moderate hazard and in which careful engineering and geologic studies have shown the feasibility of corrective engineering to mitigate unfavorable site conditions.

Summer: Extreme Heat

HOT SPOTS
In 1995, summer heat claimed 1,021 lives in the United States and was the #1 cause of death.

Again, in 1998, extreme heat was the #1 weather-related killer in the United States.

The 10-year average (1989 to 1998) for heat-related fatalities is 144 deaths per year.

The highest recorded temperature in Colorado (through 1998) was 118°F.

The southeastern corner of Colorado has the highest average number of days with temperatures greater than or equal to 100°F in the state. The average is 16 to 18 days per year.

In the Denver metro area, the summer of 2000 had more than 60 days of over 90°F temperatures.

Heat stroke, heat exhaustion, heat syncope, and heat cramps are the major human risks from exposure to extreme heat. Livestock and crops are also at risk.

Infrastructure such as roads, bridges and railroad tracks may suffer damage from extreme heat conditions.

Extreme heat can affect water supplies and increase fire risks.

Extreme heat may affect and even cause shortages in energy supplies. In general, energy use increases when people run air conditioners and fans throughout a heat spell.

Beating the August Heat – Windsurfing and Swimming at Bear Lake Photo by COEM

Beating the August Heat – Snowboarding on St. Mary's Glacier Photo by COEM

(Sources: FEMA 1997; www.nws.noaa.gov/om/severe_weather/sum_96.htm; www.nws.noaa.gov/om/severe_weather/sum_98.htm; http://hpccsun.unl.edu/coop/atlas/temps100.gif)

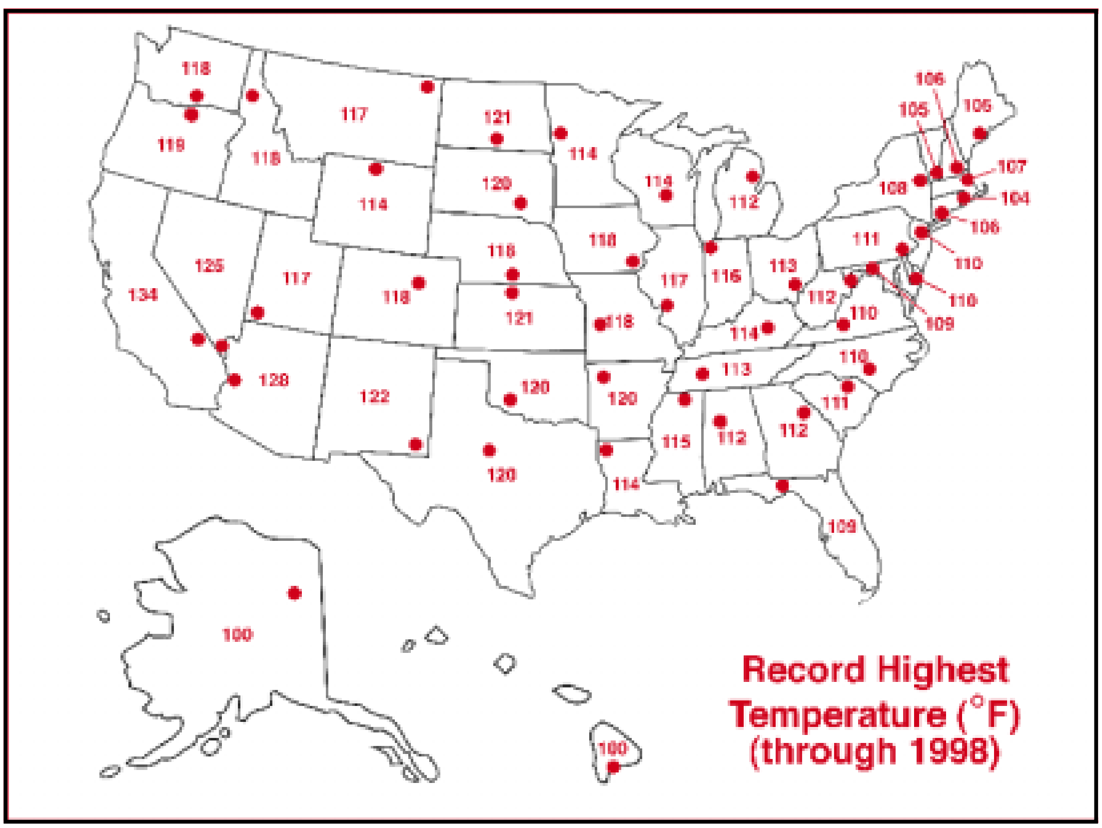
Heat Index/Heat Disorders			
Danger Category	Danger Category	Heat Disorders	Apparent Temperature (°F)
IV	Extreme Danger	Heatstroke or sunstroke imminent.	>130
III	Danger	Sunstroke, heat cramps, or heat exhaustion likely; heat stroke possible with prolonged exposure and physical activity.	105-130
II	Extreme Caution	Sunstroke, heat cramps, and heat exhaustion possible with prolonged exposure and physical activity.	90-105
I	Caution	Fatigue possible with prolonged exposure and physical activity.	80-90
Adapted from FEMA 1997			

The following tables reflect the serious nature of extreme temperatures in the United States.

Notable Heat Waves in the United States: 1980-2000			
Year	Location	Fatalities	Damage Costs** ($ billions)
1980*		10,000	44.0
1988*		5000 +	56.0
1993*	Southeast States	?	1.1
1998*	Southern States	200 +	6.0-9.0
1999*	Eastern States	~256	1.0
2000	Southcentral, southeast States	~140	>4.0
*Refer to Billion!! Dollar Disaster Events 1980-2000. **Reported in1998 dollars.			
Source:www.ncdc.noaa.gov/ol/reports/billionz.html			

Summary of Reported Deaths and Injuries Due to High Extreme Temperatures in the United States: 1996-1998		
Year	Deaths	Injuries
1995	1,021	-
1996	36	129
1997	81	530
1998	173	633
1999	502	1,477
2000	158	469
2001	166	445
2002	167	378
2003	36	174
Total	2,340	4,235
Sources: www.nws.noaa.gov/om/severe_weather/		

Highest Recorded Temperatures in the United States: through 1998			
State	Temp °F	State	Temp °F
Alabama	112	Montana	117
Alaska	100	Nebraska	118
Arizona	128	Nevada	125
Arkansas	120	New Hampshire	106
California	134	New Jersey	110
Colorado	118	New Mexico	122
Connecticut	106	New York	108
Delaware	110	North Carolina	110
Florida	109	North Dakota	121
Georgia	112	Ohio	113
Hawaii	100	Oklahoma	120
Idaho	118	Oregon	119
Illinois	117	Pennsylvania	111
Indiana	116	Rhode Island	104
Iowa	118	South Carolina	111
Kansas	121	South Dakota	120
Kentucky	114	Tennessee	113
Louisiana	114	Texas	120
Maine	105	Utah	117
Maryland	109	Vermont	105
Massachusetts	107	Virginia	110
Michigan	112	Washington	118
Minnesota	114	West Virginia	112
Mississippi	115	Wisconsin	114
Missouri	118	Wyoming	114
Source: www.ncdc.noaa.gov/ol/climate/severeweather/a-thigh.gif			



Reprinted from http://www.ncdc.noaa.gov/ol/climate/severeweather/a-thigh.gif

The following excerpts describe two very memorable hot summers in Colorado - 2000 and 1934. Most remember the summer of 2000 …

"… The highlight of the year (2000) was the new record for number of 90 degrees (days) set in a year. During 2000 … the hot summer months had 61 days of 90 degrees or warmer which set a record for the number of days with 90 degrees or higher … The old record was 60 days in 1994."

- From "Denver's 2000 Annual Weather Statistics" by the National Oceanic and Atmospheric Administration at http://ww.crh.noaa.gov/den/cli/annsum00.html.

Some may remember the summer of 1934 …

"… Among all summers in the 20th Century, the summer of 1934 remains on top of the list of hot summers in Colorado. … June 1934 was plenty hot across Colorado, especially east of the mountains where most stations ended the month 4 to 6°F above their long-term average. July, however, was the killer. For 17 consecutive days in mid July, temperatures approached or exceeded the century mark on the plains. In southeastern Colorado, readings approached 110°F. … The heat continued into August with seemingly endless days with temperatures of 100 degrees or higher out on the plains. Cheyenne Wells, for example, recorded 21 days in July 1934 with temperatures at or above 100°F with another 9 days during the first half of August."

- From "A Look at the Past – Hot Summers of the 20th Century" by Nolan J. Doesken in Colorado Climate, Summer 2000 Vol. 1, No. 3, p. 8.

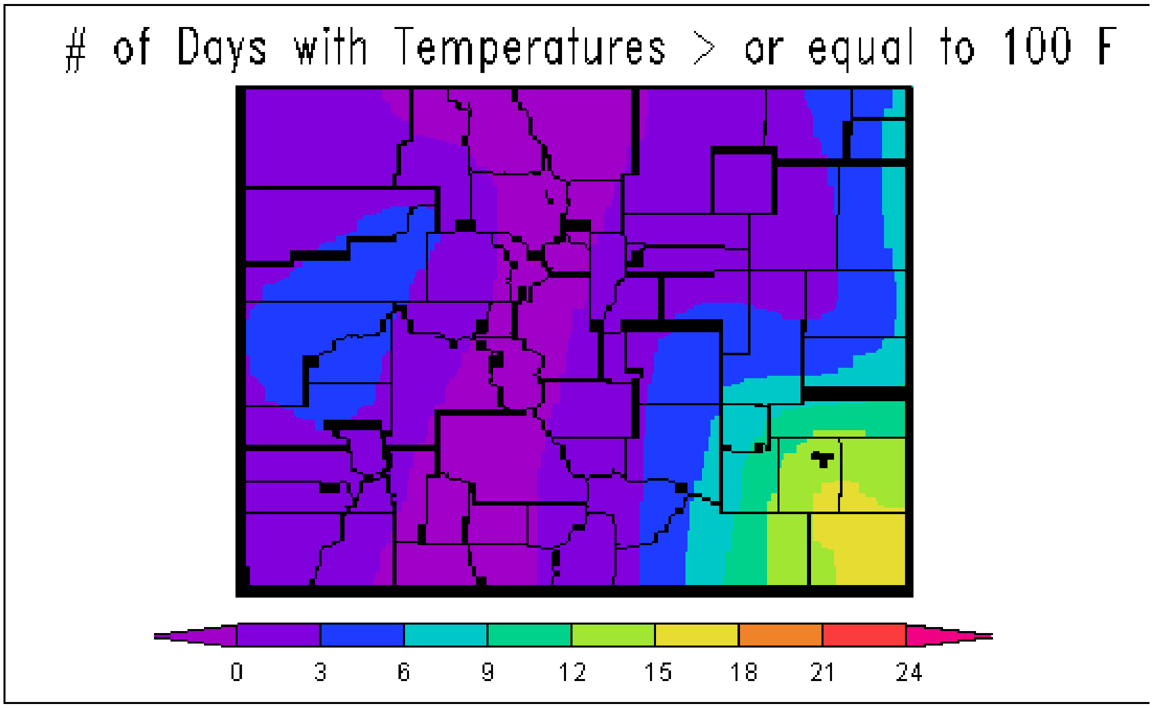
Beating the August Heat - Kayaking in the Park
Photo by Marilyn S. Gally, COEM

The following table shows the reported high temperatures in Colorado by county. Most data reflects the thirty-year period from 1961 to 1990. The data was recorded at Natural Resources Conservation Service (U.S.D.A.) Temperature and Precipitation Stations (TAPS). Data is not available for every county.

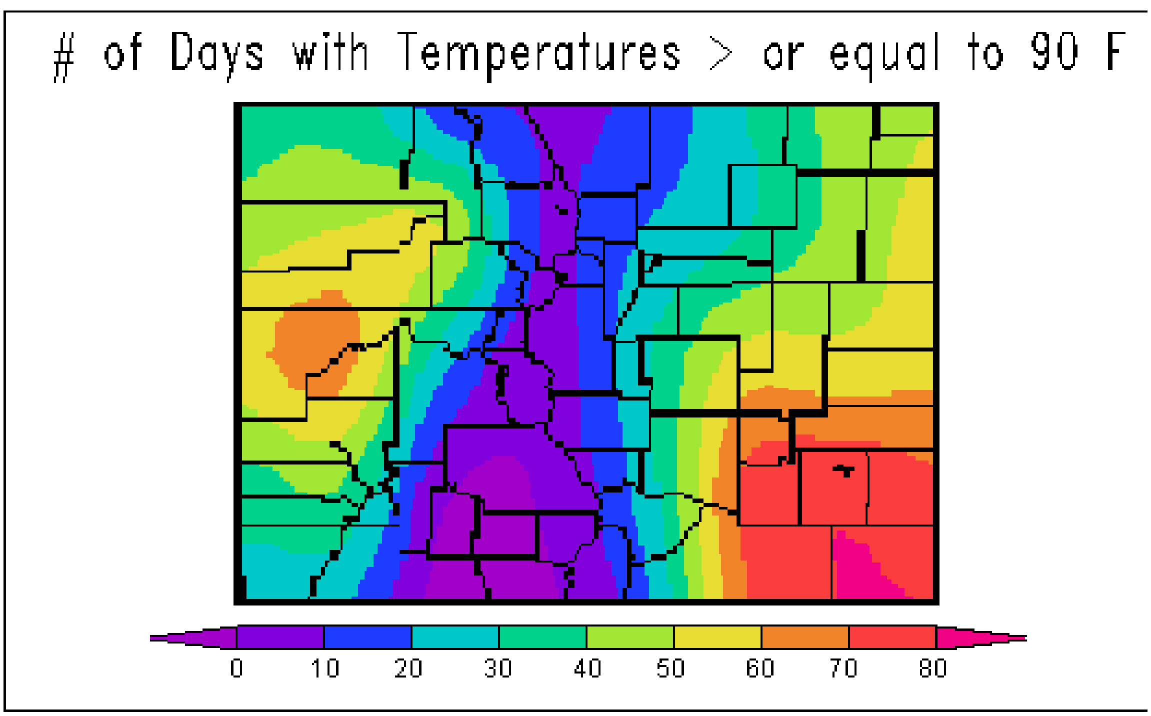
Summary of Extreme High Temperatures in Colorado by County: 1961-1990			
County	Temperature (°F)*	County	Temperature (°F)*
Adams	105	La Plata	102
Alamosa	96	Lake	86
Arapahoe	108	Larimer	102
Archuleta	99	Las Animas	103
Baca	111	Lincoln	NA
Bent	112	Logan	110
Boulder	106	Mesa	108
Chaffee	95	Mineral	97
Cheyenne	108	Moffat	104
Clear Creek	84	Montezuma	101
Conejos	95	Montrose	110
Costilla	97	Morgan	107
Crowley	NA	Otero	110
Custer	94	Ouray	91
Delta	106	Park	95
Denver	103	Phillips	109
Dolores	99	Pitkin	NA
Douglas	99	Prowers	109
Eagle	100	Pueblo	108
El Paso	99	Rio Blanco	108
Elbert	100	Rio Grande	93
Fremont	105	Routt	98
Garfield	104	Saguache	NA
Gilpin	NA	San Juan	88
Grand	94	San Miguel	97
Gunnison	98	Sedgwick	109
Hinsdale	98	Summit	98
Huerfano	101	Teller	NA
Jackson	96	Washington	NA
Jefferson	103	Weld	NA
Kiowa	110	Yuma	NA
Kit Carson	107		

*As recorded at a Natural Resources Conservation Service (U.S.D.A.) Temperature and Precipitation Stations (TAPS)
Note: Not all data covers a 30-year period.
Source: www.wcc.nrcs.usda.gov/water/climate/

The maps on the following page show the average number of days with temperatures greater than or equal to 90 and 100 degrees Fahrenheit. County boundaries are outlined. Note that parts of Baca County in the southeastern corner of the state, may have 80 or more days of 90°F or greater temperatures. Most of the county may experience fifteen to eighteen days of 100°F or greater.



Adapted from http://hpccsun.unl.edu/coop/atlas/temps100.gif.



Adapted from http://hpccsun.unl.edu/coop/atlas/temps90.gif

Thunderstorms

thunderstorm - a transient storm of lightning and thunder, usually with rain and gusty winds. May also be called a 'thunder event.

DROPS IN THE BUCKET

Thunderstorm and lightning events occur when the conditions are right:
Unstable, warm air rises swiftly,
Moisture forms clouds and rain, and
Air currents are lifted upward due to mountains, colliding weather fronts (cold and warm), or sea breezes.

The National Weather Service (NWS) classifies a thunderstorm as severe if:
Wind speeds reach 58 mph or greater,
A tornado is produced, or
Surface hail of 0.75" or greater is dropped.

The National Weather Service estimates that more than 100,000 thunderstorms occur each year in the continental United States; fortunately only about 10% are classified as "severe."

Worldwide, about 1,800 to 2,000 thunderstorms are in existence in a given second. That calculates to over 16 million a year.

Thunderstorms may produce deadly and damaging tornados, winds, hailstorms, lightning, and flash floods. Mitigation efforts are directed at these components.

Flash floods are the number one thunderstorm killer; lightning is second.

In the past 25 years, severe thunderstorms were involved in over 300 federal disaster declarations.

An average thunderstorm is roughly 15 miles in diameter and lasts about 30 minutes.

During a thunderstorm, straight-line wind speeds can exceed 100 mph. Tornado winds can exceed 200 mph.

Sources: FEMA, 1997; U.S. Dept. of Commerce, 1994

Refer to specific sections for more information on flash floods, hailstorms, lightning, tornados, and windstorms.

Tornado in Morgan County in 1996
Photo by Marie Goedert of Fort Morgan, CO

Fort Collins Colorado. Taken from atop CSU Atmospheric Science building.Photo by Stephen Hodanish, reprinted with permission.

THUNDERSTORM DEATHS, INJURIES, AND PROPERTY DAMAGE IN THE UNITED STATES: 1996-2003

WEATHER TYPE	DEATHS	INJURIES	DAMAGE ($MILLIONS)
Lightning	374	2,369	303.3
Tornadoes	506	9,128	8,352.2
Wind	208	3,095	4,130.6
Hail	4	513	7,630.6

Source: www.nws.noaa.gov/om/hazstats.shtml

IBHS Loss Data for Selected Storms: 1994-1998	
County	Total Losses ($)
Jefferson	328,968,831
Denver	315,511,606
El Paso	165,981,365
Arapahoe	146,018,176
Boulder	68,183,408
Pueblo	64,625,579
Adams	63,607,939
Weld	59,078,943
Morgan	31,551,830
Larimer	29,855,803
Logan	21,291,182
Prowers	16,484,195
Bent	8,853,819
Douglas	6,591,590
Phillips	1,858,566
Otero	1,852,440
Teller	825,531
Fremont	654,914
Washington	574,464
Park	561,560
Yuma	541,105
Elbert	419,725
Kiowa	415,786
Crowley	403,729
Baca	369,441
Clear Creek	268,054
Mesa	235,082
Cheyenne	228,353
Routt	205,547
Kit Carson	184,765
Pitkin	184,676
Sedgwick	180,200
Moffat	173,315
Las Animas	135,140
Summit	126,581
Eagle	123,566
Chaffee	115,182
Grand	104,012
Montrose	100,152
Lincoln	95,219
Gilpin	93,366
Garfield	87,401
Costilla	53,540
Custer	43,427
Ouray	39,816
Huerfano	39,451
Rio Grande	32,523
La Plata	29,186
Lake	29,023
Alamosa	28,312
Archuleta	25,251
Montezuma	19,471
Rio Blanco	12,682
Conejos	9,352
Gunnison	8,352
Mineral	4,501
Delta	4,428
Source: IBHS 2001	

The table on the left contains information compiled from individual claim losses supplied by the Institute for Business & Home Safety's (IBHS) insurer members. To fill the Colorado Office of Emergency Management's request for information, IBHS identified the catastrophes affecting Colorado and provided a database. Storms included were:

IBHS Catastrophe Paid Loss Database for Colorado: 1994-1998		
Catastrophe ID Number	Event	Dates
CO1994-16	Wind, Hail	10/1/94
CO1994-17	Wind, Hail	10/4-5/94
CO1994-87	Wind, Hail, Tornados, Flooding	4/25-27/94
CO1994-96	Wind, Hail, Tornados, Flooding	7/14-17/94
CO1995-41	Wind, Hail, Tornados, Flooding	5/16-19/95
CO1995-45	Wind, Hail, Tornados, Flooding	6/5-11/95
CO1996-76	Wind, Hail, Tornados	5/22-23/96
CO1996-84	Wind, Hail, Tornados, Flooding	7/25-28/96
CO1996-93	Wind, Hail	10/29-30/96
CO1997-31	Wind, Hail, Flooding	8/11-12/97
CO1997-33	Wind, Hail, Tornados, Snow, Flood	10/25-28/97
CO1998-52	Wind, Hail, Tornados, Flooding	5/22-26/98
CO1998-70	Wind, Hail, Tornados, Flooding	10/16-19/98
Source: Institute for Business & Home Safety 4/10/2001		

Losses were categorized as home or business. Type of loss included building, contents, time element, and other. Claims were grouped together at three levels: zip code, county, and state.

Tornados

tornado - a localized, violently destructive windstorm occurring over land, especially in the midwestern U.S., and characterized by a long, funnel-shaped cloud, composed of condensation and containing debris, that extends to the ground and marks the path of greatest destruction.

TORNADO TIDBITS

- Over the past 25 years, more than 100 federal disaster declarations included damage associated with tornados.
- About 1,000 tornados a year are generated by severe thunderstorms. Earthquake-induced fires and wildfires may also produce tornados.
- The path of a single tornado can be dozens of kilometers long, but tornados rarely last longer than 30 minutes.
- A tornado can move as fast as 125 mph. Internal wind speeds can exceed 300 mph.
- Powerful tornados have lifted and moved objects weighing more than 300 tons a distance of 30 feet and tossed homes greater than 300 feet away from their foundations.
- In 1974, 148 tornados in 13 states killed 315 people. This was the largest recorded tornado event.
- On average, most tornados in Colorado occur in June, followed by July and May, mainly during afternoon or evening hours.
- The June 1990 tornado in Limon caused $12 million in damages.
- Sources: After-Action Report: Limon Tornado June 6, 1990; FEMA 1997

Tornado in Morgan County in 1996
Photo by Marie Goedert of Fort Morgan, CO

On June 9, 2004, "a tornado swept through the City of Sterling in northeastern Colorado. It hit at 7 p.m. and lasted for roughly 20 minutes, whipping through 29 square blocks." The most significant structural damage was at a car dealership. There were two minor injuries and 2,500-3,000 homes were affected.
-Svaldi, Shanley, and Nicholson in the 6/11/04 The Denver Post

Measuring Tornados: Fujita Tornado Scale	
Scale Value	Wind Speed* Range and Description of Damage
F0	40-72 mph: Light damage. Some damage to chimneys; tree branches broken off; shallow-rooted trees pushed over; sign boards damaged.
F1	73-112 mph: Moderate damage. Lower limit is the beginning of hurricane wind speed. Roof surfaces peeled off; mobile homes pushed off foundations or overturned; moving autos pushed off roads.
F2	113-157 mph: Considerable damage. Roofs torn off houses; mobile homes demolished; boxcars pushed over; large trees snapped or uprooted; light-object missiles generated.
F3	158-206 mph: Severe damage. Roofs and some walls torn off well-constructed houses; trains overturned; most trees in forest uprooted; heavy cars lifted off ground and thrown.
F4	207-260 mph: Devastating damage. Well-constructed houses leveled; structures with weak foundations blown off some distance; cars thrown; large missiles generated.
F5	261-318 mph. Incredible damage. Strong frame houses lifted off foundations and carried considerable distances to disintegrate; automobile-sized missiles fly through the air in excess of 100 yards; trees debarked.
Source: Adapted from FEMA 1997	*Wind speeds in the range are defined by Fujita to be "the fastest ¼ mile wind."

The following table lists the reported number of tornado events, deaths, injuries, and damage costs in the United States by state from 1950 to 1994.

SUMMARY OF REPORTED DEATHS, INJURIES, AND DAMAGE COSTS IN THE UNITED STATES: 1950-1994				
STATE	EVENTS	DEATHS	INJURIES	DAMAGE COSTS* ($MILLIONS)
Alabama	886	275	4483	609.7
Alaska	1	0	0	0.0
Arizona	155	3	139	58.2
Arkansas	854	279	3697	516.9
California	214	0	83	63.3
Colorado	1113	2	157	67.9
Connecticut	61	4	699	385.4
Delaware	52	2	73	5.6
Florida	2009	82	2594	498.3
Georgia	888	111	2662	1,117.4
Hawaii	28	0	5	5.5
Idaho	115	0	7	4.8
Illinois	1137	182	3599	823.8
Indiana	886	218	3641	1,648.7
Iowa	1374	61	1774	709.2
Kansas	2110	199	2267	1,213.0
Kentucky	373	105	2333	282.6
Louisiana	1086	134	2169	593.2
Maine	82	1	18	7.1
Maryland	145	2	117	38.7
Massachusetts	134	99	1334	617.8
Michigan	712	237	3214	345.0
Minnesota	832	87	1707	1,015.4
Mississippi	1039	386	5344	541.6
Missouri	1166	155	2252	739.4
Montana	238	2	20	26.0
Nebraska	1673	51	1046	632.5
Nevada	48	0	2	1.5
New Hampshire	72	0	25	9.1
New Jersey	112	0	67	53.1
New Mexico	390	3	105	25.8
New York	249	21	170	184.1
North Carolina	590	81	1778	365.2
North Dakota	799	22	288	97.3
Ohio	648	173	4156	965.5
Oklahoma	2300	217	3184	1,065.7
Oregon	44	0	0	50.9
Pennsylvania	451	77	1076	615.0
Rhode Island	8	0	23	2.0
South Carolina	423	47	1047	244.6
South Dakota	1139	11	243	169.2
Tennessee	502	181	2592	228.3
Texas	5490	475	7452	1,955.9
Utah	76	0	5	0.9
Vermont	32	0	10	3.5
Virginia	279	25	460	124.7
Washington	55	6	303	2.1
West Virginia	83	2	90	21.6
Wisconsin	844	94	1442	410.8
Wyoming	434	2	81	34.1

* CPI Adjusted Dollars.
Source: www.spc.noaa.gov/archive/tornadoes/st-trank.html

Tornadic events have affected every state in the country to some degree. Texas reported the most tornado events, with 5,490. Colorado was tenth, with 1,113. Texas also reported the most fatalities and injuries attributed to tornados for the same time period: 475 deaths and 7,452 injuries. Not surprisingly, the state also led in damages, reporting close to $2 billion in damage costs, as adjusted for the Consumer Price Index (CPI). Colorado reported 2 deaths and 157 injuries, ranking it 38th and 31st in the country for the same time period. Damage costs were estimated at approximately $68 million, placing Colorado 30th.

TORNADO HAZARD IN COLORADO

On May 29, 2001 a tornado ripped through the community of Ellicott, in eastern El Paso County. The community incurred extensive damage, especially to a mobile home park and a public school. Damage to the school was estimated at over $6 million. The following photos demonstrate the extent of the damage.

Damage from tornado in Ellicott on May 29, 2001
Photos provided by El Paso County Sheriff's Office

While most tornado damage is caused by violent winds, most tornado injuries and deaths result from flying debris.

- From After-Action Report: Limon Tornado June 6, 1990

Federal, state, and local entities work toward public awareness and understanding. Public shelter stations, such as the restrooms at the Denver International Airport, are constant reminders to travelers to be aware of weather conditions.

Tornado shelter sign by restroom at Denver International Airport Photo by COEM

The following tables summarize data collected for Colorado from 1950 through 1995. For statistics on tornados in specific years, refer to www.disastercenter.com/colorado/tornado.html. For statistics on individual tornados by county refer to www.tornadoproject.com/alltorns/cotorn.htm.

Summary of Reported Events, Deaths, Injuries, and Damage Costs in Colorado due to Tornados: 1950-1995

Years	Number	Deaths	Injuries	Damage Costs Adjusted ($Millions)
1950-59	107	0	16	1.94
1960-69	137	2	20	2.49
1970-79	204	0	25	9.74
1980-89	336	0	62	38.99
1990-95	377	0	34	14.95
TOTAL	1161	2	157	68.11
AVG/YR	25	0	3	1.48

Source: www.disastercenter.com/colorado/tornado.html

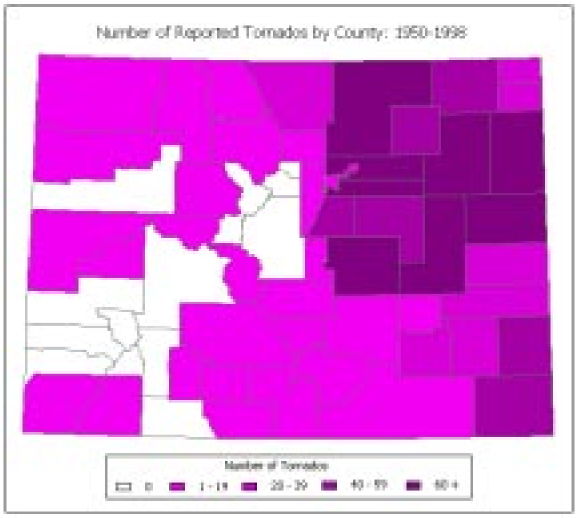
Summary of Reported Events, Deaths, and Injuries due to Tornados in Colorado by County: 1950-1995

County	Number of Events	Deaths	Injuries
Adams	99	0	43
Alamosa	7	0	0
Arapahoe	53	0	0
Baca	40	0	4
Bent	19	0	0
Boulder	7	0	0
Chaffee	1	0	0
Cheyenne	31	0	5
Conejos	2	0	0
Costilla	5	0	0
Crowley	11	0	0
Custer	5	0	0
Delta	1	0	0
Denver	12	0	13
Douglas	47	0	6
Eagle	1	0	0
Elbert	47	0	0
El Paso	64	0	6
Fremont	4	0	0
Grand	1	0	0
Huerfano	6	0	2
Jackson	1	0	0
Jefferson	12	0	0
Kiowa	30	0	1
Kit Carson	64	0	14
La Plata	1	0	0
Larimer	28	0	0
Las Animas	15	0	0
Lincoln	52	0	15
Logan	38	0	0
Moffat	2	0	0
Montezuma	2	0	0
Morgan	37	0	0
Otero	16	0	0
Phillips	23	0	1
Pitkin	1	0	0
Prowers	40	0	1
Pueblo	9	0	0
Rio Blanco	1	0	0
Rio Grande	2	0	0
Routt	2	0	0
Saguache	3	0	0
Sedgwick	20	2	9
Teller	3	0	0
Washington	80	0	10
Weld	173	0	13
Yuma	57	0	14

Source: www.tornadoproject.com/alltorns/cotorn.htm

An F4 tornado was recorded in Baca County on May 18, 1977.

The map below depicts the number of reported tornados from 1950 to 1998, as recorded on the National Weather Service website.



The map following this section depicts the counties in Colorado most at risk from tornados. Calculations were based on the following:

The numbers of tornados for each country were assigned a value as follows:

NUMBER OF TORNADOS	VALUE
75+	3
50-74	2
22-49	1
1-21	0.1
0	0

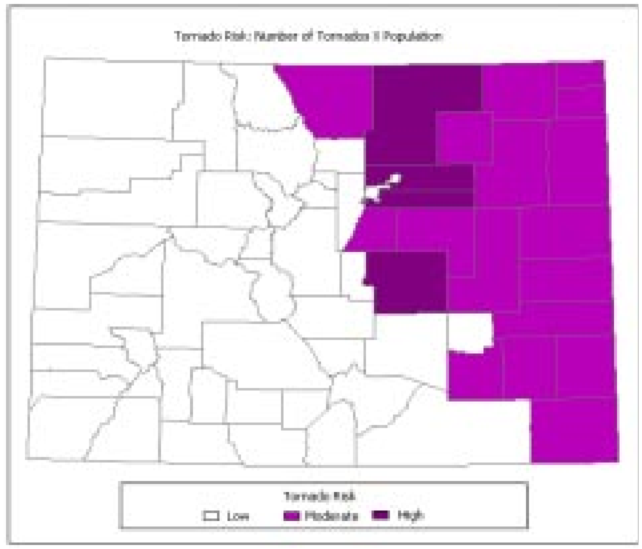
The population figures used are based on the 2000 census. Values were assigned as follows:

POPULATION	VALUE
150,000+	2
<149,999	1

The exposure values were assigned as follows:

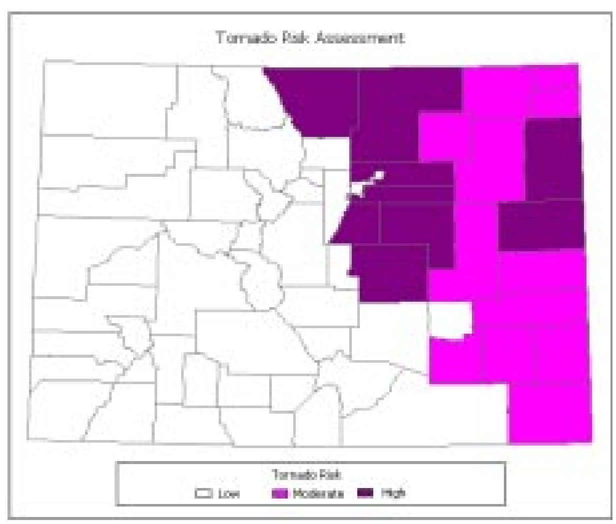
EXPOSURE ($BILLIONS)	VALUE
10.00+	3
0.50-9.99	2
>0-0.49	1
0	0

The value assigned to tornados was multiplied by the value assigned to population. The resulting values ranged from 0 to 6. Values from 4 through 6 represent areas determined to be at high risk due to the number of tornados and population. Values from 1-3 represent areas with moderate risk and values less than 1 represent areas with low risk (Tornado Risk: Number X Population). Exposure values were multiplied by areas of high and moderate risk (Tornado Risk Assessment).



Mitigation activities in high-risk areas should have priority. High-risk areas include sections of Adams, Arapahoe, Elbert, El Paso, Larimer, Weld, and Yuma Counties. Moderate risk areas include sections of Baca, Bent, Cheyenne, Douglas, Elbert, Kiowa, Kit Carson, Larimer, Lincoln, Logan, Morgan, Otero, Phillips, Prowers, Sedgwick, Washington, and Yuma Counties.

Mitigation activities should focus on improving communication and life safety activities. Improving communications includes getting, replacing, and testing warning systems such as sirens and weather radio to alert persons to tornados in the vicinity. Many areas of the state do not have severe weather alert capabilities; transmission stations should be encouraged. Life safety plans should be in place in homes, schools, institutions, etc., and plans should be exercised in regular trainings. Safe rooms in homes and community tornado shelters should be encouraged. Public education and information should be developed, improved, and disseminated on a continual basis.



Windstorms

wind – air in motion, as along the earth's surface.

WIND GUSTS

- The insurance industry spent roughly twenty-three billion dollars on wind-related catastrophic events from 1981 to 1990.

- In Colorado along the eastern slope of the Rocky Mountains, localized wind hazards known as "Chinook" winds are present. They are a result o large atmospheric movement over mountain ridges and occur during the winter.

- From 1993 through July 2000, there were 16 recorded wind events in Colorado with wind speeds reaching over 100 knots (115-116 miles per hour).

- On August 26, 1997 just southwest of Simla, in Elbert County, wind speed was recorded at 175 knots.

- Between January 1, 1993 and July 31, 2000, thei were 12 fatalities in Colorado from wind events. Thirty-one events had at least one injured persor

- The damage from fourteen major windstorms in Colorado over the past ten years is estimated to be $35,700,000.

- Source: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms; FEMA 1997

"Gusty Winds Likely" Warning Sign
Photo by COEM

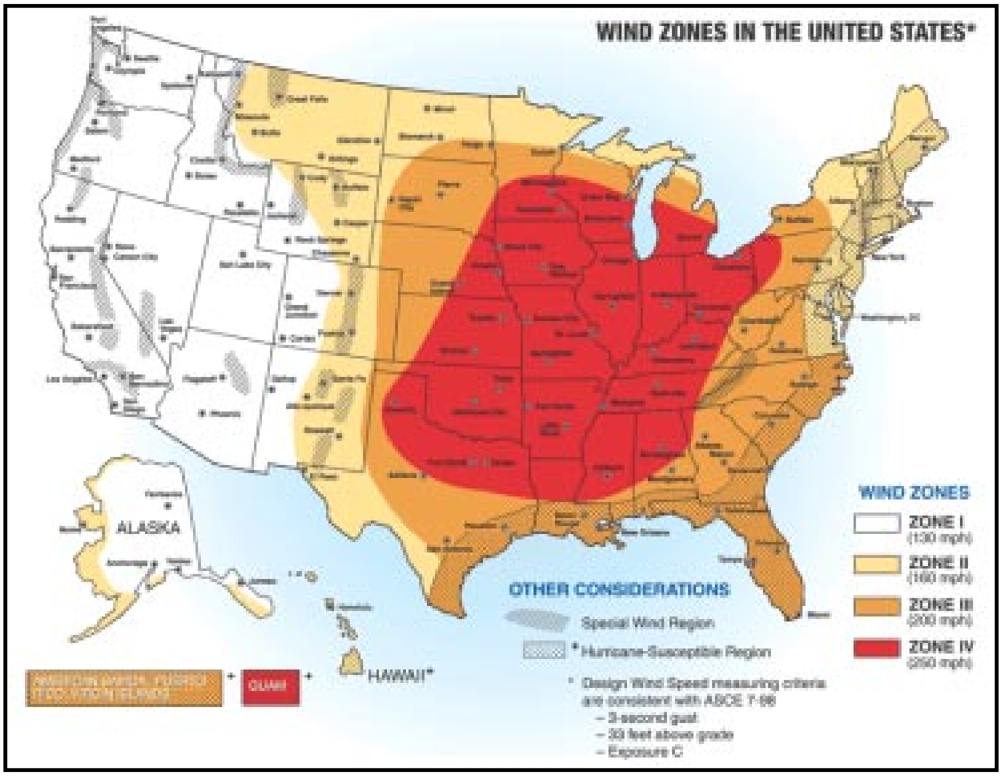

Wind and Ice Damage from April 2001 Storm
Photo by Bill Cordova, COEM

WIND HAZARD IN THE UNITED STATES

The following table shows the high number of deaths, injuries, and costs of property and crop damage attributed to wind for three recent years in the U.S. Extremely strong winds affect the lower 48 states from Texas to Maine and in special wind regions across the country (FEMA 1997). The map on the following page is reprinted from www.fema.gov. Note the special wind region in Colorado.

Summary of Reported Deaths, Injuries, and Damage Costs due to Thunderstorm and High Winds in the United States: 1996-2003			
Type	Deaths	Injuries	Property and Crop Damage ($millions)
Thunderstorm	208	3,095	4,130.6
High Winds	218	1,026	880.7
Total	426	4,121	5,011.3
Sources: www.nws.noaa.gov/om/severe_weather/			


Wind Damage to Shingles
Photo by COEM

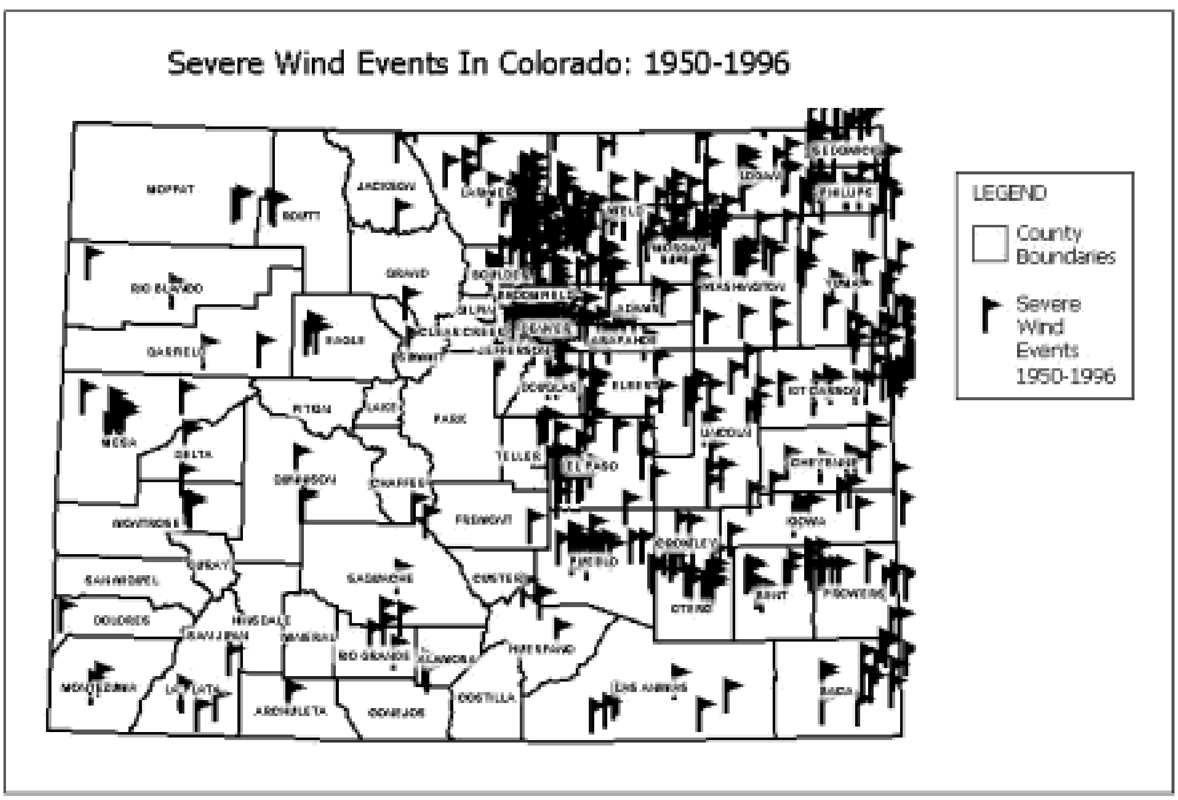


WIND HAZARD IN COLORADO

Chinook winds affect areas along the eastern slope of the Rocky Mountains during the winter. Winds may be in excess of 100 mph, but are usually of short duration and concentrated in a relatively small area when compared to large-scale events.

Downbursts, microbursts, and tornados are generated by severe thunderstorms (FEMA 1997).

The map below was generated using wind event data from FEMA Hazards U.S. software.



Five notable wind events that occurred in the past five years are described here.

- On October 29, 1996, northeast Colorado was seriously affected by high winds. High wind speeds were recorded at 101 miles per hour. One death and five injuries were reported. Many trees and powerlines went down, leaving homes and businesses without power. Damages were listed at $5.2 million.

- On February 2, 1999, the plains and Front Range foothills were pummeled with high winds measured at speeds up to 127 miles per hour during blizzard conditions. Over 3 million dollars in damage was reported. Power poles, lines and trees went down. Ten thousand were without power. Roofs were torn off homes and small planes overturned.

- On April 8, 1999, high winds threatened northeast Colorado with wind speeds up to 116 miles per hour. There was extensive damage to homes, crops, cars, power lines, trees, and tractor trailer rigs. Small grass fires started. Damages were reported at $7.2 million.

- The next day, April 9, 1999, the plains and foothills suffered more damage from high winds recorded at up to 98 miles per hour. Roofs and cars were damaged and trees, power lines and poles went down. Damages were close to $14 million.

- On two weekends in April 2001, severe winter storm conditions caused extensive damage in eastern Colorado – enough damage to receive a presidential disaster declaration. Rural electric associations and power companies estimated damages to power poles and power lines to be over $5 million. Thousands were without power for days.

- (Source: http://www4.ncdc.noaa .gov/cgi-win/wwcgi.dll?wwevent~storms)

Damage from strong winds and ice – April 2001
Photo by Bill Cordova

The following table reflects reported wind events for Colorado from January 1, 1993 through July 31, 2000.

SUMMARY OF REPORTED WINDSTORM EVENTS, DEATHS, INJURIES, AND DAMAGE IN COLORADO BY COUNTY: 1/1/93 THROUGH 7/31/00

COUNTY	NUMBER OF EVENTS	DEATHS	INJURIES	DAMAGE ($MILLIONS)
Adams	32	0	6	7.30
Alamosa	4	0	2	0.04
Arapahoe	19	0	5	0.57
Archuleta	7	1	2	0.02
Baca	24	0	3	0.14
Bent	17	1	4	0.29
Boulder	21	0	0	0.01
Cheyenne	34	0	0	0.01
Clear Creek	3	0	0	0.00
Crowley	15	0	3	0.14
Custer	1	0	0	0.00
Delta	4	0	0	0.55
Denver	68	1	24	30.48
Douglas	10	1	3	0.05
Eagle	5	0	0	0.00
El Paso	53	0	8	1.49
Elbert	26	1	6	26.21
Fremont	12	0	2	0.35
Garfield	5	1	0	0.01
Gilpin	1	0	0	0.00
Grand	16	0	0	1.70
Gunnison	2	1	0	0.00
Jackson	4	0	0	0.00
Jefferson	12	0	0	0.00
Kiowa	15	0	3	0.18
Kit Carson	37	0	1	0.11
La Plata	4	0	0	1.00
Larimer	47	0	12	0.05
Las Animas	20	0	6	0.14
Lincoln	18	0	0	0.00
Logan	46	1	10	26.23
Mesa	16	0	0	0.01
Moffat	4	0	0	0.03
Montezuma	7	0	0	0.13
Montrose	5	0	0	0.01
Morgan	58	1	16	29.83
Otero	17	0	0	0.05
Phillips	14	0	0	0.06
Pitkin	1	0	0	0.00
Prowers	28	0	3	0.15
Pueblo	31	0	13	1.15
Rio Blanco	5	0	0	0.15
Routt	4	0	0	0.01
San Juan	1	0	0	1.50
Sedgwick	37	1	12	29.25
Summit	25	-	3	0.03
Teller	23	-	8	1.41
Washington	34	1	10	29.43
Weld	103	1	5	24.10
Yuma	36	0	0	0.00
TOTAL	1,031	12	170	40.290

- No windstorms reported for Chaffee, Conejos, Costilla, Dolores, Hinsdale, Huerfano, Lake, Mineral, Ouray, Park, Rio Grande, Saguache, and San Miguel Counties.

Source: www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storm

Winter Weather

blizzard - a heavy and prolonged snowstorm covering a wide area. A blizzard combines heavy snowfall, high winds, extreme cold and ice storms.

SNOW FLAKES

- Late spring snow storms are not uncommon in Colorado. On May 3, 2001, a late spring storm hit, dumping snow across a large area of the state.
- In April 2001, a severe storm caused over $4 million in damage to rural electric association powerlines and poles. Thousands of homes were without power for days. The Denver International Airport lost power two times in two consecutive weekends due to two severe spring storms.
- Every state in the continental United States and Alaska has been impacted by severe winter storms.
- In 1997, winter storms/blizzards were the number two killer and cause of injuries that were weather-related in the United States.
- Hypothermia, carbon monoxide poisoning, and traffic accidents were the main causes of death in the United States during the "Blizzard of '96."
- The Superstorm of March 1993 caused over $2 billion in property damage in twenty states and Washington D.C. At least 79 deaths and 600 injuries are attributed to this storm event.
- The October 1997 blizzard dumped as much as 31 inches of snow on metro Denver.
- In 1983, an extremely bitter cold spell occurred with mercury dipping to 21 degrees below zero, the coldest recorded temperature in over 20 years.
- Poor visibility from blowing snow caused a 46-car pile-up on I-25 in the middle of Denver in 1989.
- 4000 travelers were stranded at the Denver International Airport during the blizzard of 1997.
- The October 1997 blizzard cost air carriers more than $20 million.
- Sources: FEMA, 1997; Colorado Office of Emergency Management 2001; www.nws.noaa.gov/om/severe_weather/

Winter Storm Driving Conditions Alert Along Interstate 70 on May 3, 2001 Photo by COEM

Winter Storm Conditions on May 3, 2001
Photo by COEM

Winter Storm Conditions on May 3, 2001
Photo by COEM

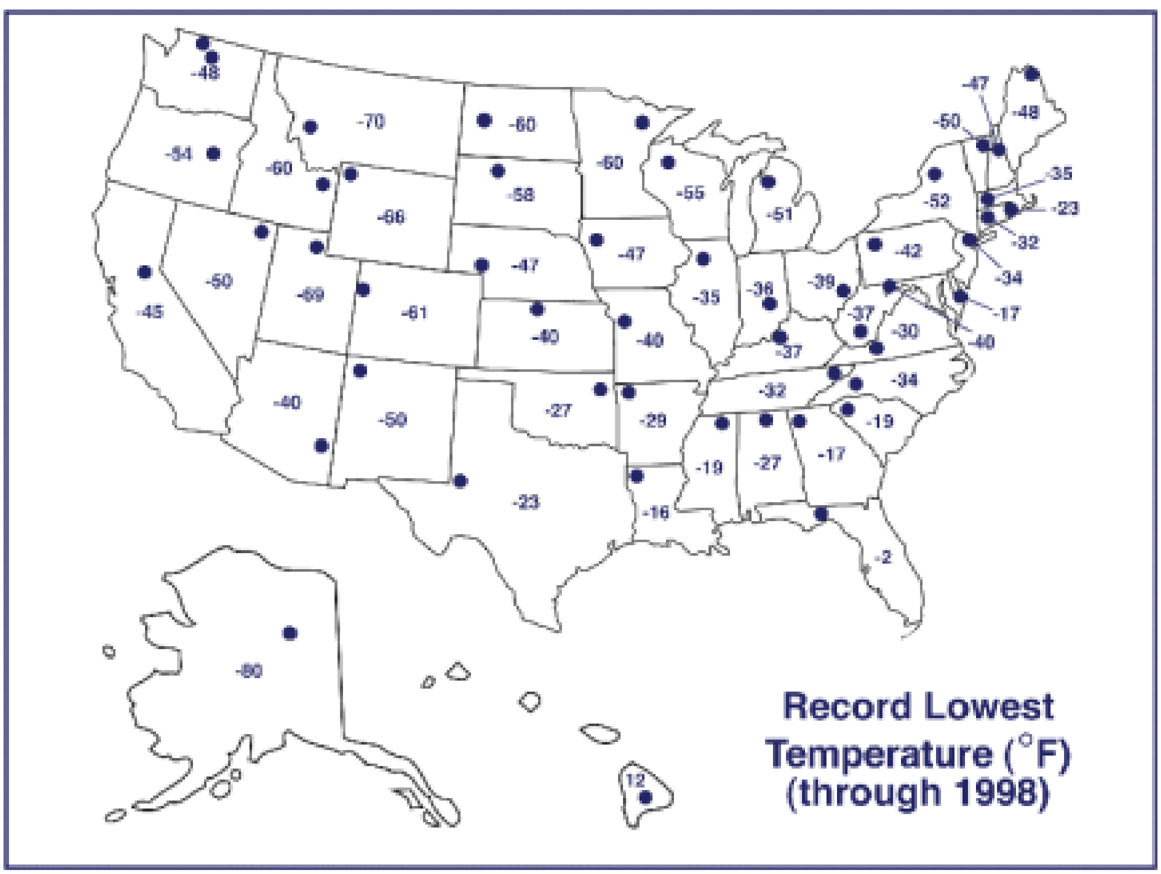
WINTER WEATHER HAZARD IN THE UNITED STATES

The following information, compiled from National Weather Service statistics, is a summary of the reported number of deaths, injuries, and property and crop damage costs attributed to extreme cold temperatures, winter storms, and ice in the United States. Data reported is for 1996 through 1998.

Summary of Reported Deaths, Injuries, and Damage Costs Due to Extreme Cold Temperatures, Winter Storms, and Ice in the United States: 1996-2003				
Year	Deaths	Injuries	Property Damage ($Million)	Crop Damage ($Million)
Cold	192	113	31.2	1,642.1
Storm	374	2,423	3,968.2	104.9
Ice	14	374	2.5	0.0
Total	580	2,910	4,001.9	1,747.0
Sources: www.nws.noaa.gov/om/severe_weather/				

The map below and the following table show the lowest recorded temperature for each state. Data reflects information collected through 1998. Colorado registered the fifth lowest temperature (-61°F), recorded in Moffat County.

Lowest Recorded Temperatures in the United States: through 1998			
State	Temp °F	State	Temp °F
Alabama	-27	Montana	-70
Alaska	-80	Nebraska	-47
Arizona	-40	Nevada	-50
Arkansas	-29	New Hampshire	-47
California	-45	New Jersey	-34
Colorado	-61	New Mexico	-50
Connecticut	-32	New York	-52
Delaware	-17	North Carolina	-34
Florida	-2	North Dakota	-60
Georgia	-17	Ohio	-39
Hawaii	12	Oklahoma	-27
Idaho	-60	Oregon	-54
Illinois	-35	Pennsylvania	-42
Indiana	-36	Rhode Island	-23
Iowa	-47	South Carolina	-19
Kansas	-40	South Dakota	-58
Kentucky	-37	Tennessee	-32
Louisiana	-16	Texas	-23
Maine	-48	Utah	-69
Maryland	-40	Vermont	-50
Massachusetts	-35	Virginia	-30
Michigan	-51	Washington	-48
Minnesota	-60	West Virginia	-37
Mississippi	-19	Wisconsin	-55
Missouri	-40	Wyoming	-66
Source: www.ncdc.noaa.gov/ol/climate/severeweather/a-thigh.gif			



Reprinted from http://www.ncdc.noaa.gov/ol/climate/severeweather/a-tlow.gif

WINTER WEATHER HAZARD IN COLORADO

Included in this section are extreme cold and severe storms. Avalanche information is located in its own section.

Two of the past three presidential declarations have been related to severe winter weather events. In 2003, Colorado received a presidential declaration for snow emergency for the winter snowstorms of March 17th through the 20th. Twenty-nine counties requested assistance. The state and communities received $6.2 million in federal funds through the public assistance program. No hazard mitigation funds were included with the emergency declaration. In April 2001, the state incurred severe winter storms including high winds and ice, snapping power poles and downing lines, leaving many residents and businesses without power. the state requested and received a presidential disaster declaration for severe winter storms. Over $550,000 was received in hazard mitigation funds. In October 1997, the state declared an emergency for severe snowfalls.

EXTREME COLD

The table to the right reflects the lowest temperatures recorded in Colorado by county by the Natural Resources Conservation Service (U.S.D.A.) at their Temperature and Precipitation Stations (TAPS). Most county data covers a 30-year period.

The following table lists extreme cold events in Colorado from 1983 through the 1999/2000 season. Deaths, injuries, and property and crops damages attributed to the event are listed.

SUMMARY OF EXTREME COLD TEMPERATURES IN COLORADO BY COUNTY: 1961-1990

County	Extreme Temperature (°Fahrenheit)	County	Extreme Temperature (°Fahrenheit)
Adams	-33	La Plata	-35
Alamosa	-42	Lake	-55
Arapahoe	-32	Larimer	-39
Archuleta	-42	Las Animas	-32
Baca	-26	Lincoln	NA
Bent	-29	Logan	-35
Boulder	-34	Mesa	-36
Chaffee	-32	Mineral	-45
Cheyenne	-30	Moffat	-61
Clear Creek	-33	Montezuma	-27
Conejos	-34	Montrose	-23
Costilla	-38	Morgan	-32
Crowley	NA	Otero	-28
Custer	-41	Ouray	-22
Delta	-31	Park	-54
Denver	-25	Phillips	-33
Dolores	-36	Pitkin	NA
Douglas	-35	Prowers	-28
Eagle	-51	Pueblo	-30
El Paso	-35	Rio Blanco	-48
Elbert	-38	Rio Grande	-41
Fremont	-25	Routt	-45
Garfield	-38	Saguache	NA
Gilpin	NA	San Juan	-39
Grand	-46	San Miguel	-32
Gunnison	-60	Sedgwick	-37
Hinsdale	-38	Summit	-46
Huerfano	-36	Teller	NA
Jackson	-50	Washington	NA
Jefferson	-41	Weld	NA
Kiowa	-27	Yuma	NA
Kit Carson	-29		

*As recorded at NRCS (U.S.D.A.) Temperature and Precipitation Stations (TAPS). Note: Not all data covers a 30-year period.
Source: www.wcc.nrcs.usda.gov/water/climate/

NOTABLE EXTREME COLD EVENTS IN COLORADO: 1983-1999/2000

Date	Description, including Deaths, Injuries, Crop and Property Damage ($Million)
1983	Cold spell. Readings to -21°F, coldest recorded temperature in 20 years.
1989	Extreme cold, snow, wind. Main airport closed. Poor visibility. 46-car pile-up on I-25
3/23-27/95	Freeze. West Colorado. Readings below critical values in orchard areas. 10% of crops damaged.
4/11/95	Extreme Cold. Arapahoe area. Readings to 13°F. Wheat damaged. ~ $1M crop damage.
1/17-18/96	Extreme wind chill. Southeast. Wind chills from –30 to –50°F.
2/1-4/96	Extreme wind chill. Southeast plains. Wind chill -25 to -50°F. Lows Pueblo -26°F, Colorado Springs -18°F.
3/24-25/96	Extreme wind chill. Southeast. Bitter cold, gusty. Wind chill -25 to -40°F.
12/16-18/96	Extreme wind chill. Eastcentral, northeast. Readings –30 to -45 °F. Southcentral, southeast. Wind chill –20 to –40°F. Denver area. Low -9°F.
12/25-26/96	Extreme wind chill. Southeast. Wind chills of –20 to -35°F.
1/11-16/97	Extreme wind chill. Southeast, foothills. Wind chills –25 to -35°F. Northeast. Wind chill –25 to -50°F.
4/09-10/97	Extreme cold. Eastcentral. Single digit temper-atures, highs below freezing, freezing drizzle, light snow. Schools closed 1-2 days for ice. Many car accidents.
4/12-13/97	Freeze. West. Temperatures dropped below critical levels for most fruit varieties. Majority of stone fruits lost, most apples and pears survived. ~ $9M crop damage
10/24-25/97	Blizzard. Front range, east. Snow to 4' in foothills. Gusts to 70 mph. Wind chill –25 to -40°F. State of emergency declared. 5 deaths; 2 injuries; 24,000+ cattle lost
6/6/98	Extreme cold. East central. Record cold AM temperatures, lows below freezing. Crop and garden damage.
12/18-24/98	Extreme cold. Denver, northeast. 6 days dipped below 0°F. Low -19°F. Power outages, cracked water pipes. 5 deaths; 15 injuries
1/2-3/99	Extreme wind chill. Far eastern Colorado. Readings below -35°F.
4/16/99	Extreme cold. Mesa County. Ruined part of fruit crop. Lows 10s to 20s°F. ~$8.8M crop damage
6/5/99	Extreme cold. Southwest. Late freeze destroyed grapes and vegetables. ~$0.004M crop damage

Source:www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms

SEVERE STORMS

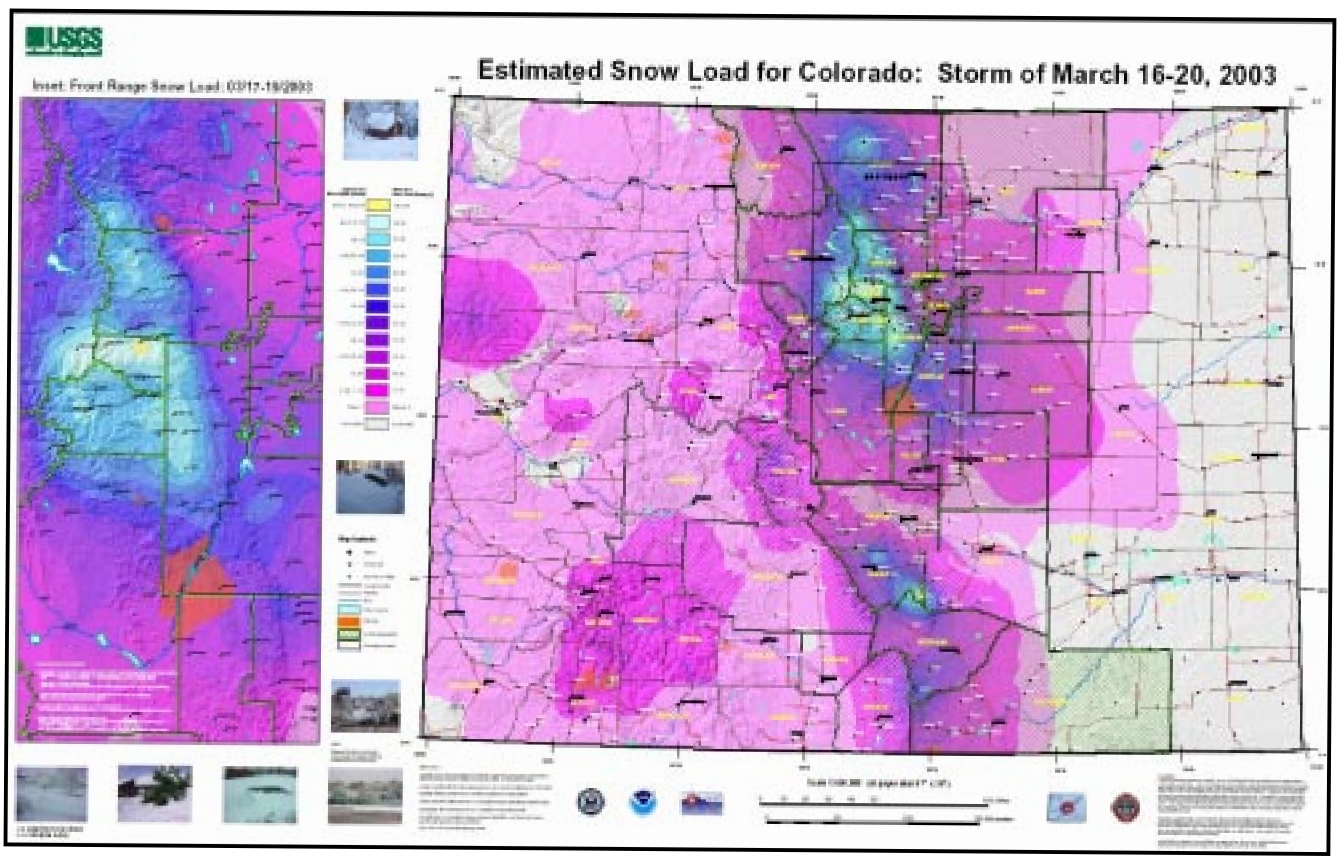
Severe Winter Storms of 2003

The map on this page was provided by the USGS and FEMA. It depicts the snow load for the state for the severe winter storms of March 2003.

Twenty-nine counties were designated for public assistance: Jackson, Grand, Summit, Park, Fremont, Custer, Weld, Huerfano, Las Animas, Teller, Costilla, Clear Creek, Gilpin, Alamosa, Saguache, El Paso, Chaffee, Gunnison, Elbert, Douglas, Arapahoe, Larimer, Boulder, Denver, Morgan, Jefferson, Adams, Pueblo, and Broomfield.

The state and communities received reimbursement of over $6 million for expenditures incurred over a 72-hour period through the public assistance program. Storm costs exceeded $8 million. Snow load did millions of dollars in property damage, especially to roofs and porches.

Photos to the right were taken in Golden at Camp George West by Colorado Office of Emergency Management staff. The emergency operations center was activated for three 24-hour shifts. State officials closed state government for a day for all employees except essential personnel because transportation conditions in the metro area were so difficult. Many locals governments were also closed.



Severe Storms of 2001 and 1997

In April 2001, severe storms ravaged the eastern portion of the state. Over $5,000,000 in damage was incurred, mainly in broken power poles and downed power lines. Thousands went without power for days. The State of Colorado requested and received a presidential disaster declaration.

Damage from April 2001 Storm
Photo provided by Bill Cordova, COEM

The table below reflects severe storm events. Main characteristics of each storm event are listed. Deaths, injuries, and property and crop damages attributed to the events are also listed.

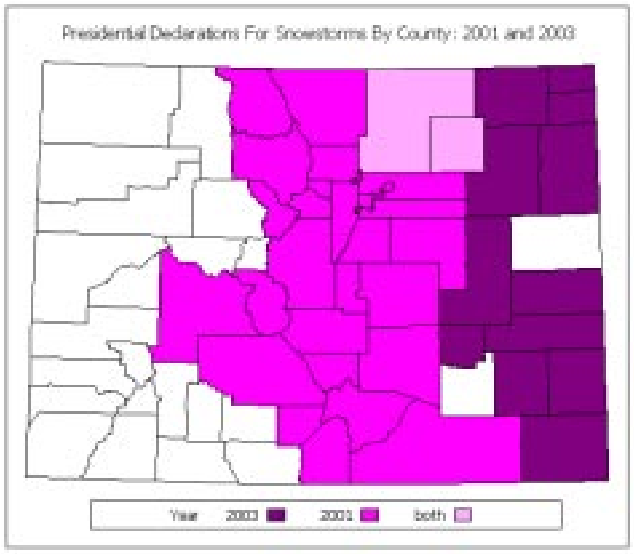
In October 1997, an early blizzard paralyzed the Front Range and eastern sections of the state. Snow was recorded up to four feet in areas of the foothills. Wind gusts were measured up to 70 miles per hour and the wind chill ranged from –25 to –40. At times visibilities dropped to zero. Four thousand people were stranded at the Denver International Airport. The Colorado Department of Transportation, the State Patrol, and the National Guard were called upon to conduct safety and rescue missions to aid stranded motorists. Over 100 cars were abandoned along the highways. Roads were closed throughout the area. The Governor declared a state emergency. Losses included five deaths and two injuries, 24,000 cattle, and greater than $1,200,000 in property losses. Air carriers estimated their losses at $20,000,000.

Snow Drifts from October 1997 Blizzard
Photo reprinted from Colorado Department of Transportation

NOTABLE WINTER STORM EVENTS IN COLORADO: 1983-2003	
DATE	DESCRIPTION, INCLUDING DEATHS, INJURIES, AND DAMAGES*
1983	Snowstorm. Denver. Snow over 21″.
12/26-27/87	Snowstorm, strong winds. Northeast area. Drifts to 5′. Highways closed.
1989	Extreme cold, snow, wind. Main airport closed. Poor visibility. I-25 46-car pile-up
1/10/93	Heavy Snow. $500K property
2/10-11/93	Heavy snow, winds. Mountains, east. Snow to 1′, drifts to 2′. $50K property
2/17-20/93	Heavy snow. Mtns, SW. Mtn snowfall to 60.5″. Avalanches. Road closures. 2 injuries; $50K property
2/21-25/93	Heavy snow. N, C, SW mtns, SW. I-70 avalanche. Cars, truck buried. $50K property
3/26-28/93	Heavy snow. Mountains, southwest. Snow to 2′. Avalanche damage. $5K property
1/26/94	Heavy snow. E, FR. Snow to 1′. 1 death
2/11-12/94	Heavy snow. Front Range, Denver. Snow 6-12″. I-25 40-car pile-up. 2 injuries; $50K property
4/9/95	Heavy snow. Mountains. 1 death
10/14-17/94	Heavy snow. SW. High winds. Snow 1-5′. Avalanches. 200 hunters cut off. 5 injuries; 2 deaths
1/15-18/95	Heavy snow. High country. Snow totals 1-4′. Injuries from avalanches. 4 injuries
2/8-14/95	Heavy snow. FR. 8′ in mountains. Avalanches, road closures 2 deaths $1.7M property
9/20-21/95	Heavy snow. East, Yuma County. Powerlines down. Snow to 10″. $5M crop; $5K property
11/1-12/2/95	Heavy snow. Northern mountains, front range foothills. Snow up to 1′. Icy roads, fog, blowing snow. 1 death
2/20-21/96	Heavy snow. C, N, SW mtns. Snow to 2′. I-70 20-car pile-up. Roads closed. Avalanches. 1 death; 2 injuries
2/22/96	Winter storm. Mtns. Snow to 1′. 40 mph gusts. Road closures. 30+ vehicles in pile-ups on I-70. 5 injuries
3/13-15/96	Winter storm. SE, SC. Snow to 2′. Power lines down. $600K property
10/24-25/97	Blizzard. FR, east. Snow to 4′ in foothills. State emergency declared. 24,000 cattle died. Losses estimated at $20M for air carriers. 5 deaths, 2 injuries; $1.2M property
11/27-28/97	Winter storm. SC, CFR. Highways closed. Winds to 40 mph. Snow to 4′. 1 death
12/24-25/97	Heavy snow. South, CFR. Snow up to 1′. 1 death
2/18/98	Heavy Snow. Palmer Divide to SE mtns, foothills. Snow to 1′. I-25 accidents. 1 death; 4 injuries
4/2/98	Heavy snow. SC, SE. Snow to 1.5′. 1 death
11/8-9/98	Winter storm. W, mtns. Snow to 2′. Gusts to 67 mph. 10,000 without power, downed lines caused 20 fires. $300K property
3/19/99	Winter storm. E. Accidents on I-70. 1 injury
4/11-22/01	Presidential disaster declaration for winter storms. Power poles damaged. $5M+ damage
3/17-20/03	Presidential snow emergency declaration. Public Assistance program triggered. $6+ in public assistance.
*Thousands (K), millions (M), mtn-mountains, C-central, E-east, W-west, S-south, N-north, FR-Front Range.	
Sources: Colorado Office of Emergency Management 2000; www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms	

Every county is at risk from severe winter weather effects including cold temperatures, ice, heavy snow, and high winds. It is not unusual for motorists and residents to become stranded or for power outages to occur. Heavy snow loads and frozen pipes cause damage to residences and businesses. Late season heavy snows cause plant and crop damages.

As the map below shows, two-thirds of the counties in the state were declared in 2001 and/or 2003.



Preparedness and mitigation efforts include, but are not limited to promoting 72-hour kits for the home, workplace, and car, dressing appropriately for the weather and activity, promotinng personal beacons for outdoor activities, weatherproofing critical facilities and other structures like homes, and promoting weather radios and emergency backup power for critical facilities.

Living snowfence along Highway 93 north of Boulder
Photo by CDEM

Snowfence at Arapahoe Basin on Highway 6
Photo by CDEM

Winter Weather Awareness Week is an annual event. The week is a collaborative effort between the National Weather Service, the Governor's Office, and the Colorado Office of Emergency Management. The Governor signs an honorary proclamation. Press releases and public information are distributed and available online. The National Weather Service provides training. The document above is an example of an honorary proclamation.

Snowfences are used in Colorado to prevent snow from blowing. The first is an example of a snow fence used to retain snow on a ski trail. The second photo (on the next page) is an example of a living tree snowfence.